INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING (ES)**				
Course Title	**EMBEDDED SYSTEM PROGRAMMING**				
Course Code	BESD01				
Program	M.Tech				
Semester	I				
Course Type	Core				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. B. Surekha Reddy, Assistant Professor				

I COURSE OVERVIEW:

An embedded system programming course typically covers designing, programming, working with embedded systems. embedded C is an extension to the standard C Programming Language. It focuses on the knowledge and skills required to define the functionality of the embedded systems.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Embedded System Programming	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	**x**	MOOC
x	Open Ended Experiments	✓	Seminars	**x**	Mini Project	**x**	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 40 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question. The emphasis on the questions is broadly based on the following criteria:

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course. The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty

Table 3: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The student has to answer any 4 questions out of five questions, each carrying 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Assignment:

To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Quiz:
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

Alternative Assessment Tool (AAT):
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center. The AAT may include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

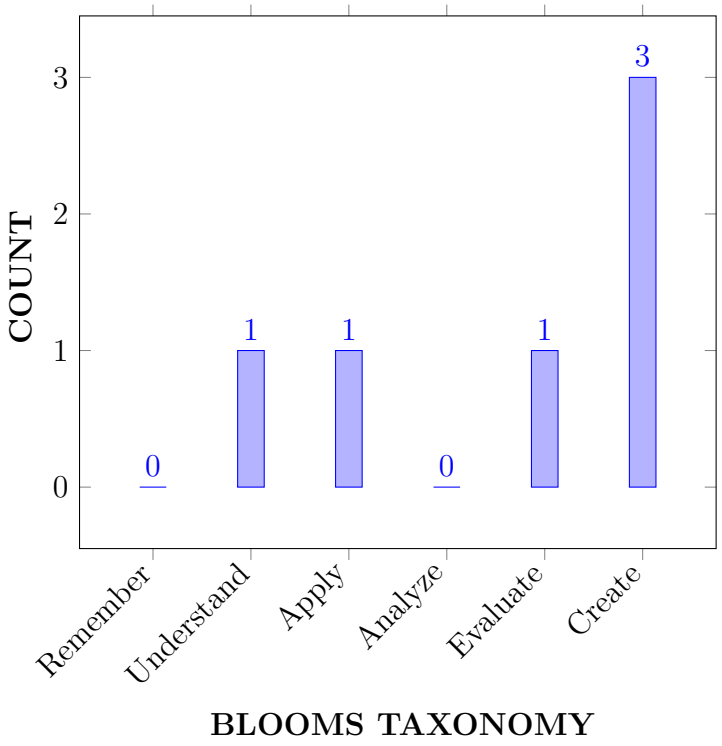
I	The importance of embedded C and microcontrollers to design real time timers with various constraints.
II	Writing, compiling, and debugging code for embedded systems.
III	Techniques for debugging and testing both software and hardware components of embedded systems.
IV	To interface with input and output devices, as well as communication interfaces commonly used in embedded systems.

VII COURSE OUTCOMES:

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

CO 1	**Summarize** the concepts of embedded C to develop the embedded C programming examples with Keil IDE and interfacing modules.	Understand
CO 2	**Choose** serial or parallel communication for transmitting the data between microcontroller and peripherals.	Evaluate
CO 3	**Develop** Embedded C language programs for, blinking the LED and interfacing of switch, LCD display, buzzer and temperature sensors to the microcontrollers.	Create
CO 4	**Build** an interface between micro controller and peripherals to provide solutions to the real world problems.	Create
CO 5	**Make use of** debugging techniques in embedded software to know step- by-step software execution process.	Apply
CO 6	**Develop** embedded system programming for different peripherals to increase the code density.	Create

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	2	SEE/CIE/AAT
PO 2	Write and present a substantial technical report / document.	2	SEE/CIE/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	1	SEE/CIE/AAT
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	3	SEE/CIE/AAT
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	3	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	✓	✓	✓
CO 2	✓	✓	-	✓	✓	✓
CO 3	✓	✓	-	✓	✓	✓
CO 4	✓	✓	-	✓	✓	✓
CO 5	✓	✓	-	✓	✓	✓
CO 6	✓	✓	-	✓	✓	✓

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Studying Embedded C and applying it in simulation environments like Keil enables students to independently implement solutions for embedded challenges, contributing to practical development experience.	2
	PO 2	Writing code using Keil and documenting interfacing examples supports technical reporting and structured presentation of embedded designs.	4
	PO 4	Using Embedded C and interfacing modules aligns with designing and implementing embedded systems in real-world applications such as IoT, communications, and medical devices.	5
	PO 5	Developing embedded programming projects using Keil may require collaborative tasks, sharing and integrating different code modules, supporting team work.	2
	PO 6	Students are encouraged to explore and update their skills with new versions of tools like Keil IDE, contributing to lifelong learning.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Selecting appropriate communication protocols involves investigation, comparison, and a decision-making process that aligns with solving practical hardware-software integration problems.	2
	PO 2	Understanding the rationale for choosing specific protocols prepares students to write analytical reports on embedded communication interfaces.	3
	PO 4	Effective communication interface selection is essential for building reliable embedded systems used in various application domains like signal processing and IoT.	4
	PO 5	Design decisions may be made in collaborative settings, requiring creative input and responsibility sharing.	2
	PO 6	Keeping pace with evolving communication standards in embedded systems motivates students to engage in lifelong learning and continuous skill development.	3
CO 3	PO 1	Interfacing real hardware components with microcontrollers demands practical investigation and problem solving under real constraints.	3
	PO 2	Documenting the design and development process of interfacing peripherals through Embedded C programming supports writing technical reports or code documentation.	4
	PO 4	Developing embedded programs for peripherals such as sensors and displays reflects real-world embedded design expertise.	5
	PO 5	Such programming activities are often done in teams, requiring collaboration in hardware/software integration.	3
	PO 6	Practicing with peripherals and coding methods fosters interest in continuous exploration of advanced components and frameworks.	3
CO 4	PO 1	Designing microcontroller-peripheral interfaces to solve real-world problems requires investigative development and problem-solving skills.	3
	PO 2	Design processes and technical decisions made while solving real-world problems can be documented as substantial technical reports.	3
	PO 4	Designing microcontroller interfaces for real-time problems demonstrates skills expected from a professional embedded engineer.	6
	PO 5	Problem-solving through embedded interfacing often occurs in multidisciplinary teams, requiring effective collaboration.	4
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	3
CO 5	PO 1	Applying debugging tools to fix embedded systems issues requires independent investigation and decision-making.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Understanding and applying debugging techniques contributes to creating well-documented and tested embedded applications, which is critical in technical documentation.	3
	PO 4	Debugging is an essential step in design validation of embedded systems. Proficiency in this ensures robust real-world solutions.	3
	PO 5	Debugging often requires working in groups to review code, reproduce bugs and test collaboratively.	2
	PO 6	New debugging techniques and tools constantly evolve, encouraging students to stay updated and engage in lifelong learning.	3
CO 6	PO 1	Creating optimized embedded solutions requires analytical exploration and design decisions that support development of efficient systems.	2
	PO 2	Creating optimized code for various peripherals involves detailing the logic and structure in technical documents or code documentation.	4
	PO 4	Increased code efficiency is a key goal in professional embedded system design, especially in constrained environments.	5
	PO 5	Programming and optimizing embedded systems often involves sharing responsibilities with peers for collaborative review and feedback.	2
	PO 6	Staying updated with optimization techniques and learning from toolchain updates demonstrates commitment to lifelong learning.	3

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	4	3	-	5	3	2
CO 2	4	2	-	4	3	3
CO 3	6	3	-	5	4	3
CO 4	6	2	-	6	6	3
CO 5	4	2	-	3	3	3
CO 6	4	3	-	5	3	3

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 10	PO 12
	6	6	9	10	7	8
CO 1	66.66	50	-	50	42.85	25
CO 2	66.66	33.33	-	40	42.85	37.5
CO 3	100	50	-	50	57.14	37.5
CO 4	100	33.33	-	60	85.71	37.5
CO 5	66.66	33.33	-	30	42.85	37.5
CO 6	66.66	50	-	50	42.85	37.5

XIV COURSE ARTICULATION MATRIX (PO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	-	2	2	1
CO 2	2	1	-	2	2	2
CO 3	3	2	-	2	2	2
CO 4	3	1	-	2	3	2
CO 5	2	1	-	1	2	2
CO 6	2	2	-	2	2	2
TOTAL	**14**	**9**	**-**	**11**	**13**	**11**
AVERAGE	**3**	**2**	**-**	**1**	**2**	**1**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	-	Tech - Talk	-	Certification	-
Term Paper	✓	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVI SYLLABUS:

MODULE I	**EMBEDDED C PROGRAMMING**
	Introduction to 'C' programming, Difference between C & Embedded C, storage Classes, Data Types Controlling program flow, Arrays, Functions, Memory Management, Pointers, Arrays and Pointers, Pointer to Functions and advanced topics on Pointers, Structures and Unions, Data Structures, Linked List, Stacks, Queues Conditional Compilation, Pre-processor directives, File operations, Bitwise operations, Typecasting.
MODULE II	**TIMERS & COUNTERS AND SERIAL COMMUNICATION PROGRAMMING**
	Introduction to Timers & Counters, Difference between Timer and Counter, Description of SFR associated with Timers & Counters, Programming of Timers & Counters. Introduction to Serial Communication, Types of Serial Communication, Description of SFR associated with Serial Communication, Programming of UART.
MODULE III	**PROGRAMMING FOR EXTERNAL INTERFACES**
	Interfacing Circuit Description of LED's, Programming of LED's Interfacing, Interfacing of Seven Segment Display, Programming of 7 Segment Display Interfacing, Interfacing Circuit Description of 16 x 2 LCD, Programming of 16 x 2 LCD. Interfacing Circuit of Switches & Keyboard Matrix, Programming of Keyboard Matrix & Switches, Programming & Controlling of motors in Embedded System.
MODULE IV	**EMBEDDED SYSTEM DEVELOPMENT**
	The integrated development environment, Types of files generated on cross compilation, Simulators. emulators and debugging, Target hardware debugging, Boundary Scan, Embedded software development and tools. testing on host machine.
MODULE V	**CASE STUDIES**
	Design of Embedded Systems using Microcontrollers for applications in the area of communication and automotive. (GSM/GPRS, CAN, ZigBee).

TEXTBOOKS

1. Michael J. Pont, "Embedded C", A Pearson Education, 2nd edition, 2009.
2. RajKamal, "Embedded Systems, Architecture Programming and Design", Tata McGraw Hill, 2nd edition, 2008.

REFERENCE BOOKS:

1. Jonathan W. Valvano – Brookes / Cole, "Embedded Microcomputer Systems, Real Time Interfacing", Thomas Learning, 1st Edition, 1998.

XVII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	https://lms.iare.ac.in/index?route=course/details
CONTENT DELIVERY (THEORY)			
2	Introduction to 'C' programming	CO1	T1-3.1-3.2
3	Difference between C & Embedded C	CO1	T1-3.3-3.4
4	Storage Classes	CO1	T1-3.3-3.4
5	Data Types	CO1	T1-3.7
6	Controlling program flow	CO1	T1-3.5
7	Arrays	CO1	T1-3.6
8	Functions	CO1	T1-5.1.1
9	Memory Management	CO1	T1-.1.1,5.1.2
10	Pointers	CO2	T1-5.2
11	Arrays and Pointers	CO1	T1-7.10.2-3
12	Pointer to Functions	CO1	T1-3.5
13	Advanced topics on Pointers	CO1	T1-4.2
14	Structures	CO1	T1-4.6
15	Unions	CO1	T1-4.7
16	Data Structures	CO2	T1-4.10.6
17	Linked List	CO2	T1-4.11
18	Stacks	CO2	T1-5.1.1
19	Queues Conditional Compilation	CO2	T1-5.1.1
20	Pre-processor directives	CO2	TT1-5.11
21	File operations	CO2	T1-5.3.2
22	Bitwise operations	CO2	T1-5.3.3,5.4
23	Typecasting	CO2	T1-5.4.2
24	Introduction to Timers & Counters	CO3	T1-5.5
25	Difference between Timer and Counter	CO3	T1-7.1,7.2
26	Description of SFR associated with Timers & Counters	CO3	T1-7.7.2
27	Programming of Timers & Counters	CO3	T1-7.3,7.4
28	Introduction to Serial Communication	CO4	T1-3.5
29	Types of Serial Communication	CO4	T1-7.8
30	Description of SFR associated with Serial Communication	CO4	T1-7.8.1,8.2
31	Programming of UART	CO4	T1-7.10,11
32	Interfacing Circuit Description of LED's	CO4	T1 7.10.3.3

33	Programming of LED's Interfacing	CO3	T1-5.3
34	Interfacing of Seven Segment Display	CO4	T1-7.10.
35	Programming of 7 Segment Display Interfacing,	CO4	R3-P184
36	Interfacing Circuit Description of 16 x 2 LCD	CO4	R3-P184
37	Programming of 16 x 2 LCD	CO3	R3-P185
38	Interfacing Circuit of Switches & Keyboard Matrix	CO4	R3-P191
39	Programming of Keyboard Matrix & Switches	CO4	R3-P190
40	Programming & Controlling of motors in Embedded System	CO4	R3-P190
41	The integrated development environment,	CO 4	T1:5.1.1
42	Types of files generated on cross compilation	CO5	T1:7.3,7.4
43	Types of files generated on cross Simulators	CO5	T1:5.1.1
44	Types of files generated on cross emulators	CO5	T1:4.2
45	Types of files generated on cross debugging	CO5	T1:1-7.8
46	Target hardware debugging	CO6	T1:7.4
47	Boundary Scan	CO6	T1:7.2
48	Embedded software development and tools	CO6	T17-7.2
49	Testing on host machine	CO6	T1:5.3.2
50	Design of Embedded Systems using Microcontrollers for applications in the area of communication and automotive.	CO6	T1:4.2
51	Design of Embedded Systems using Microcontrollers for application of GSM/GPRS	CO6	T1:5.3
52	Design of Embedded Systems using Microcontrollers for applications using CAN	CO6	R3:P185
53	Design of Embedded Systems using Microcontrollers for applications using ZigBee)	CO6	R3-P191
DISCUSSION OF QUESTION BANK			
54	EMBEDDED C PROGRAMMING	CO1	T1:4.6
55	TIMERS & COUNTERS AND SERIAL COMMUNICATION PROGRAMMING	CO2	T1:5.11
56	PROGRAMMING FOR EXTERNAL INTERFACES	CO3	T1:7.1
57	EMBEDDED SYSTEM DEVELOPMENT	CO4	T1: 7.10
58	CASE STUDIES	CO6	T1:4.2

Course Coordinator: **HOD, ECE**
Dr. B. Surekha Reddy, Assistant Professor

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering (ES)**				
Course Title	**Microcontrollers and Programmable Digital Signal Processing**				
Course Code	BESD02				
Program	M.Tech				
Semester	I				
Course Type	Core				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mrs. P. Ganga Bhavani, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	Microprocessors and Microcontrollers
B.Tech	-	-	Digital Signal Processing

II COURSE OVERVIEW:

This course is intended to provide fundamentals of ARM Cortex-M3 Processor and LPC 17XX Microcontroller architectures and their features. It includes the architectures of the Cortex-M3, instruction set summary, Programmable DSP processor. It is used in the applications of microcontrollers programming models and programmable digital signal processors.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Microcontrollers and Programmable Digital Signal Processing	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE):

The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

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Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted. CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Assignment / Quiz and 10 marks for Alternative Assessment Tool (AAT). Two CIE examinations are Compulsory and sum of the two exams, along with the scores obtained in the assignment / Quiz and AAT shall be considered for computing the final CIA of a student in a given course.

Advance notification for the conduction of Assignment / Quiz / AAT is mandatory and the uploading and conduction lies with the office of planning, monitoring & continuing studies.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIE-1	CIE-2	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Assignment / Quiz	5 Marks	5 Marks		10 Marks
Alternative Assessment Tool (AAT)	5 marks	5 marks		10 marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:

The assignments develop different skills and increase their knowledge base significantly. It provides the evidence for the faculty that the students have achieved the goals. It helps the faculty to evaluate the student's understanding of the course. Assignment will be evaluated for 5 marks. The assignment has to either handwritten / typed and uploaded to the Samvidha portal at the end of either CIE1 or CIE2, based on the questions provided by the course coordinator for that semester.

Quiz:
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2.
Alternative Assessment Tool (AAT):
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. The AAT may include tech talk, case studies, seminars, term paper, open ended experiments, partial reproduction of research work, oral presentation of research work, developing a generic tool-box for problem solving, report based on participation in create-a-thon, makea-thon, code-a-thon, hack-a-thon conducted by reputed organizations / any other. etc.

VI COURSE OBJECTIVES:

The students will try to learn:

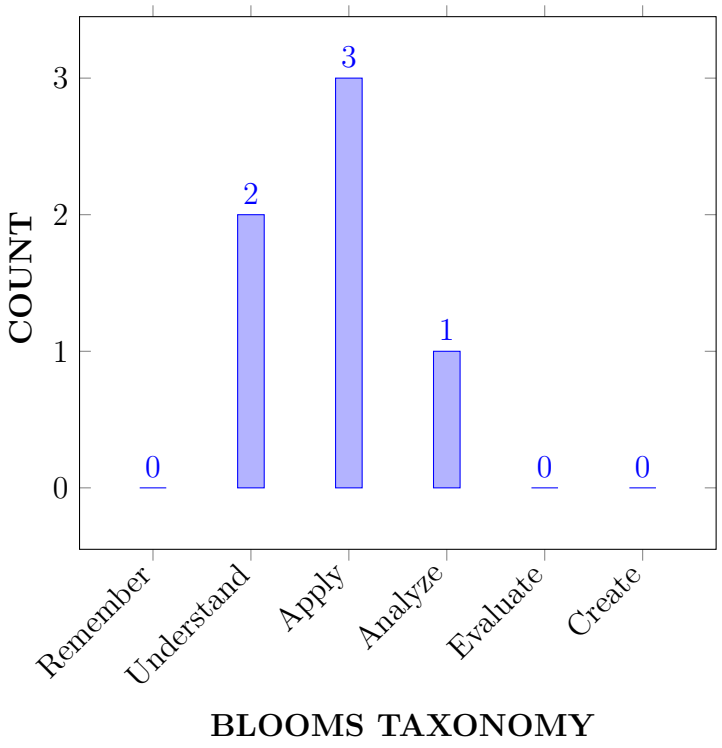
I	The programming models of ARM processors core-based System on Chip with several features / peripherals based on requirements of embedded applications.
II	The architectural view of various Programmable DSP Processors..
III	The design and development of embedded applications by utilizing the ARM processor core and DSP processor-based platform.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the Internal architecture and memory operations of ARM Cortex M3 processor for interfacing microprocessor applications	Understand
CO 2	**Analyze** Exceptions handler mechanism to minimize interrupt latency using Nested Vectored Interrupt Controller	Analyze
CO 3	**Construct** the high level of integration in embedded applications using LPC 17XX Microcontroller	Apply
CO 4	**Demonstrate** various computational building blocks of programmable DSP architectures using interfacing of memory and I/O peripherals	Understand
CO 5	**Identify** the CPU architecture, peripherals, and development tools for the TMS320C6000 digital signal processors	Apply
CO 6	**Develop** the application for digital signal processing using code composer studio tool	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	2	CIE/SEE/AAT

PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program	2	CIE/SEE/AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	3	CIE/SEE/AAT

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	✓	-	✓	✓	-	-
CO2	-	-	-	✓	-	-
CO3	✓	-	✓	✓	-	-
CO4	-	-	-	✓	-	-
CO5	✓	-	-	✓	-	-
CO6	✓	-	✓	✓	-	

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Out-comes	PO'S	Justification for mapping (Students will be able to)	No. of Key com-petencies matched.
CO1	**PO 1**	Understand the concepts of ARM Cortex-M3 processor by applying Scientific principles and methodology, Use creativity to establish architecture , identify Problem formulation for interfacing problems, Implement different applications by using arm processor.	**6**
	PO 3	Analyze the given problem statement and formulate the kernel, and other components in embedded systems and use creativity to establish innovative solutions for embedded system , Interpret the result on various applications	**4**
	PO 4	Develop ARM Cortex-M3 processor for various Problems in pre processors , implement advanced arm processor for real time applications	**5**
CO2	**PO 4**	Illustrate the concepts (knowledge) of task scheduling types for Soft real-time operating system and Hard Real-Time operating systems by using mathematics, science, engineering fundamentals to the solution of complex engineering problems	**6**

CO3	**PO 1**	Illustrate components of real time operating systems (knowledge) to integrate the software and hardware components (mathematical model) the design of reliable embedded system by applying the principles of mathematical model and science	**5**
	PO 3	Construct the high level of integration in embedded applications using LPC 17XX Microcontroller	**4**
	PO 4	Independently carry out research / investigation and development work to solve practical problems.	**5**
CO4	**PO 4**	Analyze (problem statement) finite state machine by applying solutions for complex engineering problems and design system components.	**6**
CO5	**PO 1**	Create (Engineering knowledge) semaphore token for the execution of one or more threads in mutual exclusion by applying the principles of mathematics, science.	**5**
	PO 4	Identify the given problem statement and solve it using synchronization or mutual exclusion by applying mathematical properties.	**5**
CO6	**PO 1**	Understand (knowledge) asynchronous communications protocol in operating systems by applying its mathematical properties.	**6**
	PO 3	Analyze the given problem statement and formulate the kernel, and other components in embedded systems and use creativity to establish innovative solutions for embedded system , Interpret the result on various applications	**4**
	PO 4	Understand (knowledge) asynchronous communications protocol in operating systems by applying its mathematical properties.	**5**

Note: For Key Attributes refer **Annexure - I**

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	6	-	4	5	-	-
CO 2	-	-	-	6	-	-
CO 3	5	-	4	5	-	-
CO 4	-	-	-	6	-	-
CO 5	5	-	-	5	-	-
CO 6	6	-	4	5	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	100	-	44.4	50	-	-
CO 2	-	-	-	60	-	-
CO 3	83.33	-	44.4	50	-	-
CO 4	-	-	-	60	-	-
CO 5	83.33	-	-	50	-	-
CO 6	100	-	44.4	50	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.
0 - 0 ≤ C≤ 5% – No correlation
1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	-	2	2	-	-
CO 2	-	-	-	3	-	-
CO 3	3	-	2	2	-	-
CO 4	-	-	-	3	-	-
CO 5	3	-	-	2	-	-
CO 6	3	-	2	2	-	-
TOTAL	**12**	**-**	**6**	**14**	**-**	**-**
AVERAGE	**3**	**-**	**2**	**2.33**	**-**	**-**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	✓	Tech - Talk	-	Certification	-
Term Paper	✓	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
-	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVII SYLLABUS:

MODULE I	**ARM CORTEX-M3 PROCESSOR**
	ARM Cortex-M3 processor: Applications, Programming model – Registers, Operation modes, Exceptions and Interrupts, Reset Sequence Instruction Set, Unified Assembler Language, Memory Maps, Memory AccessAttributes,Permissions,Bit-Band Operations, Unaligned and ExclusiveTransfers, Pipeline, Bus Interfaces
MODULE II	**EXCEPTIONS AND INTERRUPT**
	Exceptions, Types, Priority, Vector Tables, Interrupt Inputs and Pending behavior, Fault Exceptions, Supervisor and Pendable Service Call, Nested Vectored Interrupt Controller, Basic Configuration, SYSTICK Timer, Interrupt Sequences, Exits, Tail Chaining, Interrupt Latency
MODULE III	**LPC 17XX MICROCONTROLLER**
	LPC 17xx microcontroller- Internal memory, GPIOs, Timers, ADC. UART and other serial interfaces, PWM, RTC, WDT.
MODULE IV	**PROGRAMMABLE DSP (P-DSP) PROCESSORS**
	Programmable DSP (P-DSP) Processors: Harvard architecture, Multiport memory, architectural structure of PDSP- MAC unit, Barrel shifters, Introduction to TI DSP processor family.
MODULE V	**VLIW ARCHITECTURE**
	VLIW architecture and TMS320C6000 series, architecture study, data paths, cross paths, Introduction to Instruction level architecture of C6000 family, Assembly Instructions memory addressing, for arithmetic, logical operations code composer Studio for application development for digital signal processing, on chip peripherals, processor benchmarking.

TEXTBOOKS

1. Joseph Yiu, "The Definitive Guide to ARM Cortex-M3", Elsevier, 3rd Edition, 2014.
2. Venkatramani B, Bhaskar M, —Digital Signal Processors: Architecture, Programming and Applications", TMH, 2nd Edition, 2011.

REFERENCE BOOKS:

1. Sloss Andrew N, Symes Dominic, Wright Chris, —"ARM System Developer's Guide: Designing and Optimizing", Morgan Kaufman Publications
2. Steve furber, —"ARMSystem-on-ChipArchitecture", Pearson Education.
3. Frank Vahid and Tony Givargis, —"Embedded System Design", Wiley Publications
4. Technical references and user manuals on www.keil.com, www.arm.com, NXP Semiconductor www.nxp.com and Texas Instruments www.ti.com

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/electronics-and-communication-engineering-autonomous/Microcontrollers and Programmable Digital Signal Processing

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	https://lms.iare.ac.in/index?route=course/details&course_id=354
CONTENT DELIVERY (THEORY)			
2	Understanding the ARM Cortex-M3 processor: Applications	CO 1	T1: 1.1-1.5
3	Programming model.	CO 1	T1: 1.1-1.5
4	Registers Operation modes	CO 1	T1: 3.2-3.5
5	Exceptions and Interrupts	CO 1	T1: 3.5-3.7
6	Reset Sequence	CO 1	T1: 3.5-3.7
7	Study the Instruction Set	CO 1	T1: 4.1-4.2
8	Unified Assembler Language	CO 1	T1: 4.2-4.3
9	Memory Maps	CO 1	T1: 4.3-4.4
10	Memory Access Attributes	CO 1	T1:5.1-5.2
11	Permissions, Bit-Band Operations	CO 1	T1:5.2,5.5
12	Discuss the unaligned and exclusive transfers.	CO 1	T1: 6.1-6.2
13	Pipeline,	CO 1	T1: 6.1-6.2
14	Bus Interfaces.	CO 1	T1: 6.1-6.2
15	Examine the various Exceptions, Types	CO 2	T1: 7.1-7.2
16	Priority, Vector Tables	CO 2	T1: 7.1-7.2
17	Interrupt Inputs and Pending behavior,	CO 2	T1: 7.4-7.5
18	Fault Exceptions	CO 2	T1: 7.4-7.5
19	Discuss the Supervisor and Pendable Service Call,	CO 2	T2: 7.6-8.1
20	Nested Vectored Interrupt Controller.	CO 2	T2: 7.6-8.1
21	Understand the Basic Configuration	CO 2	T1: 8.2-8.5
22	SYSTICK Timer	CO 2	T1: 8.2-8.5
23	Interrupt Sequences, Exits	CO 2	T1:9.1-9.2
24	Tail Chaining	CO 2	T1: 9.1-9.2
25	Interrupt Latency.	CO 2	T1: 9.1-9.2

26	Describe the LPC 17xx microcontroller- Internal memory,	CO 3	R2:8.4,8.10
27	General purpose input and output(GPIOs)	CO 3	R2:8.4- 10
28	Working of Timers	CO 3	R2:8.4
29	Study the features of ADC,	CO 3	R2: 8.14-8.16
30	Universal asynchronous receiving and transmission(UART)	CO 3	R2: 8.14-8.16
31	Other serial interfaces	CO 3	R2: 8.16,8.17
32	Understand the concepts of PWM,	CO 3	R2:8.22
33	Real time clock	CO 3	R2:8. 27
34	Watch dog timers	CO 3	R2:8. 28
35	Describe the Programmable DSP (P-DSP) Processors	CO 4	T2: 2.1-2.2
36	Modified Bus Structures	CO 4	T2: 2.1-2.2
37	Memory Access Schemes in P-DSPs	CO 4	T2: 2.1-2.2
38	Harvard architecture model	CO 4	T2:2.2-2.4
39	VLIW architecture	CO 4	T2:2.2-2.4
40	Pipelining	CO 4	T2:2.2-2.4
41	Multi port memory organization	CO 4	T2: 2.1-2.4
42	Study the features of architectural structure of P-DSP- MAC unit	CO 4	T2:3.1-2.1
43	Barrel shifters with examples	CO 4	T2: 2.5
44	Special addressing modes in P-DSPs	CO 4	T2: 2.5
45	On-Chip Peripherals	CO 4	T2: 2.5
46	Understand the Introduction to TI DSP processor family.	CO 4	T2: 2.5
47	VLIW architecture	CO 5	T2: 2.5
48	TMS320C6000 series	CO 5	T2: 2.5
49	TMS320C6000 series architecture study,	CO 5	T2: 2.5,13.4
50	TMS320C6000 family architecture study,	CO 5	T2: 2.5-2.6
51	Understand data paths	CO 5	T2: 13.3
52	Cross paths interfacing	CO 5	T2:13.6-13.5
53	Introduction to Instruction level architecture of C6000 family.	CO 5	T2: 13.3-13.4
54	Assembly Instructions	CO 6	T2: 13.5
55	Memory addressing for Arithmetic operations.	CO 6	T2:13.6
56	Memory addressing for logical operations.	CO 6	T2:13.6
57	Code Composer Studio for application development for DSP	CO 6	T2:13.11-12
58	An Introduction to Debugging Using CCS	CO 6	T2:13.11-12
59	Understand on chip peripherals.	CO 6	T2:13.11-12
60	Processor benchmarking	CO 6	T2:13.12-14

DISCUSSION ON QUESTION BANK			
61	Systems ARM cortex-m3 processor	CO 1	T1: 1.1-1.5
62	Exceptions and interrupts	CO 2	T1: 7.1-7.2
63	LPC 17xx microcontroller	CO 3	R2:8.4-10
64	Programmable DSP processors	CO 4	T2: 2.1-2.4
65	VLIW architecture	CO 5	T2: 3.1-3.6

Course Coordinator **HOD,ECE**

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
COURSE DESCRIPTION

Branch	**Electronics and Communication Engineering(ES)**				
Course Title	**Real Time Operating Systems**				
Course Code	BESD04				
Program	M.Tech				
Semester	I				
Course Type	Professional Elective				
Regulation	IARE - MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms. M Sreevani, Assistant Professor				

I COURSE PRE-REQUISITES

Level	Course Code	Semester	Prerequisites
B.TECH	-	-	Embedded system design

II COURSE OVERVIEW

The course introduces the basic concepts and approaches in the design and analysis of real-time operating systems. It covers design considerations of real time operating systems, task scheduling, threads, multitasking, task communication and RTOS Application domains. It focuses on applications of real time operating systems includes image processing, fault tolerant applications and control systems.

III MARKS DISTRIBUTION

Subject	SEE Examination	CIE Examination	Total Marks
Real Time Operating Systems	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	**x**	MOOC
x	Open Ended Experiments	✓	Seminars	**x**	Mini Project	**x**	Videos
x	Others						

V EVALUATION METHODOLOGY

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted. CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Assignment / Quiz and 10 marks for Alternative Assessment Tool (AAT). **Two CIE examinations are Compulsory** and sum of the two exams, along with the scores obtained in the assignment / Quiz and AAT shall be considered for computing the final CIA of a student in a given course.

Advance notification for the conduction of Assignment / Quiz / AAT is mandatory and the uploading and conduction is lies with the office of planning, monitoring& continuing studies.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIE-1	CIE-2	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Assignment / Quiz	5 Marks	5 Marks		10 Marks
Alternative Assessment Tool(AAT)	5 marks	5 marks		10 marks
Semester End Examination(SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment: The assignments develop different skills and increase their knowledge base significantly. It provides the evidence for the faculty that the students have achieved the goals. It helps the faculty to evaluate the student's understanding of the course. Assignment will be evaluated for 5 marks. The assignment has to either handwritten / typed and uploaded to the Samvidha portal at the end of either CIE1 or CIE2, based on the questions provided by the course coordinator for that semester.

Quiz: It is online proctor based online examination conducted either at the end of the CIE1 or CIE2.

Alternative Assessment Tool (AAT): In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool

(AAT). The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. The AAT may include tech talk, case studies, seminars, term paper, open ended experiments, partial reproduction of research work, oral presentation of research work, developing a generic tool-box for problem solving, report based on participation in create-a-thon, makea-thon, code-a-thon, hack-a-thon conducted by reputed organizations / any other. etc.

VI COURSE OBJECTIVES

The students will try to learn

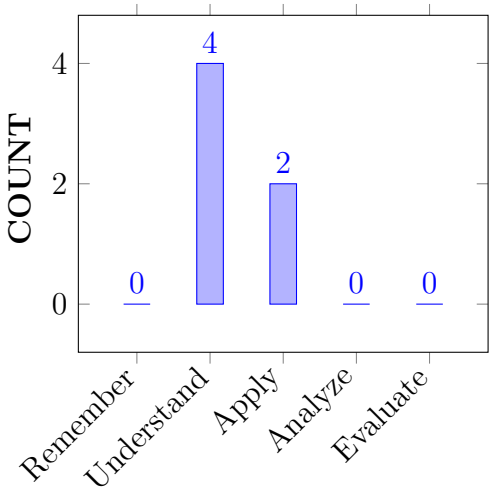
I	The basic concepts, principles of real time operating system and implementation aspects of real time concepts in embedded systems.
II	The design of real time operating system by using the concepts of Timers, I/O subsystem and Memory management units.
III	The software development process and tools such as Vxworks and mu COS for real time operating system applications.

VII COURSE OUTCOMES

After successful completion of the course, students should be able to:

CO 1	**Recall** real time operating system to provide resource management and synchronization for communication systems.	Understand
CO 2	**Compare** the soft real-time operating system and hard real-time operating systems for the priority-based task scheduling.	Understand
CO 3	**Outline** the components of real time operating systems for the design of reliable embedded system.	Understand
CO 4	**Analyze** finite state machine for task scheduling and execution in kernel models.	Apply
CO 5	**Develop** a semaphore token for the execution of one or more threads in mutual exclusion.	Apply
CO 6	**Interpret** message queue in asynchronous communications protocol for send and receive messages simultaneously.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



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VIII PROGRAM OUTCOMES

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document.
PO 3	Demonstrate a degree mastery over the area as per the area of specialization of the program.The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	3	SEE / CIE / AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	3	SEE / CIE / AAT
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	2	SEE / CIE / AAT

X MAPPING OF EACH CO WITH PO(s)

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1		-	✓	✓		✓
CO 2		-	✓	✓		✓
CO 3			✓	✓		✓
CO 4		-	✓	✓	-	✓
CO 5		-	✓	✓		✓
CO 6		-	✓	✓		✓

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO1	PO 3	**Understand** the concept of embedded systems in **real time** with characteristic requirements involved in **demonstrating** of tasks in real time scenario. **Analyze and design** key characteristics of RTOS by **using of creativity** to **interface external devices**	5
	PO 4	**Understand** the concepts of embedded real time systems for real time embedded applications by **Managing** the design process and evaluate outcomes and **interpreting** of results and **validation**	4
	PO 6	**Illustrate** the concepts **knowledge** of embedded real time systems for real time embedded applications by using **strengthen** in embedded and advanced engineering areas by **Working** with all levels of people in team	2
CO2	PO 3	**Demonstrate** typical semaphore operations by understanding embedded applications in real time scenario by**Analyzing and design innovative products Apply the complex engineering problems and their system components** by design and programming of sensor nodes in embedded systems **for solution development**	5
	PO 4	**Make use of** time constrained embedded systems using the concepts of **engineering** fundamentals to the solution of problem formulation and abstraction to establish innovative solutions for **interpretation of results and validation**	4
	PO 6	Improve the inter task communication by **Strengthen** in embedded and advanced engineering area and time constrained embedded systems using the concepts of **engineering fundamentals** to the solution of **problem formulation** and **abstraction** to establish innovative solutions.	4
CO 3	PO 3	**Contrast** the design process and evaluation outcomes for Knowledge, understanding and demonstrations of embedded applications in real time scenario for **designing** of large scale wireless sensor networks for **Solution development** or experimentation or Implementation in **Interpretation** of results and Validation	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	**Experimental Design** for large scale wireless sensor networks by**under take research** and **development projects** in the field of Embedded Systems time constrained application as a member of a small group to meet design specifications.	3
	PO 6	**Build** time constrained embedded systems using the concepts of **engineering fundamentals to the solution of problem formulation and abstraction to establish innovative solutions** using RTOS (Real Time Operating System) rapid **design** and its programming	5
CO4	PO 3	**Problem formulation and abstraction** by **Identifying** engineering problems solution development and **implementation** in various applications of embedded real time kernel objects.	4
	PO 4	**Apply** the skills and knowledge needed to serve as a professional engineer skillful at **designing** embedded systems by **Interpreting** algorithms of typical semaphore to improve the performance of real time operating system.	3
	PO 6	**Recognize** the need to engage in **lifelong learning** through continuing education and research to **improve** the performance of scheduling algorithms.	3
CO5	PO 3	**Knowledge** understanding and demonstrations of embedded applications in real time scenario by **Examine** resource synchronization methods, **Analyze** and **design** innovative products like task scheduling in MicroC.	4
	PO 4	**Apply**the skills and knowledge needed to serve as a professional engineer skilful by learning the **architecture** of multicore embedded systems in signal processing applications by **under** take research and **development** projects in the field of Embedded Systems.	4
	PO 6	**Using creativity** to establish innovative solutions by **apply** the principles and architecture of multicore embedded systems to establish **solution development** or experimentation / implementation	4
CO 6	PO 3	**Demonstrate problem formulation and abstraction** in embedded RTOS for voice over IP for in **Embedded systems.**	3
	PO 4	**Apply** the skills and knowledge needed to serve as a professional engineer skilful at **designing** embedded systems for effective use in inter vehicle communication networks to **enchance** the safety of moving vehicles.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 6	**Knowledge, understanding** and demonstrations of RTOS for fault tolerant applications by **applying the principles and methodology of** Vx works by **experimental design** of application domain.	5

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	-	-	5	4	-	2
CO 2	-	-	5	4	-	4
CO 3	-	-	4	3	-	5
CO 4	-	-	4	3	-	3
CO 5	-	-	4	4	-	4
CO 6	-	-	3	3	-	5

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	-	-	55.5	40	-	25
CO 2	-	-	55.5	40	-	50
CO 3	-	-	44	30	-	62.5
CO 4	-	-	44	30	-	37.5
CO 5	-	-	44	30	-	50
CO 6	-	-	33	30	-	62.5

XIV COURSE ARTICULATION MATRIX (PO MAPPING)

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	2	2	-	1
CO 2	-	-	2	2	-	2
CO 3	-	-	2	1	-	3
CO 4	-	-	2	1	-	1

CO 5	-	-	2	1	-	2
CO 6	-	-	1	1	-	3
TOTAL	-	-	**11**	**8**	-	**12**
AVERAGE	-	-	**1.8**	**1.3**	-	**2**

XV ASSESSMENT METHODOLOGY DIRECT

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	-	Tech - Talk	✓	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
-	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVII SYLLABUS

UNIT I	**REAL TIME OPERATING SYSTEM PRINCIPLES**
	History of operating systems, defining RTOS, classification of real-time systems, The scheduler, objects, services and key characteristics of RTOS, Tasks: Defining a task, task states and scheduling, typical task operations, typical task structure
UNIT II	**REAL TIME KERNEL OBJECTS**
	Semaphores: Defining semaphores, typical semaphore operations, typical semaphore use; Message Queues: Defining message queues, message queue states, message queue content, message queue storage, typical message queue operations; Typical message queue use other kernel objects: Pipes, event registers, signals, condition variables.
UNIT III	**RTOS DESIGN CONSIDERATIONS**
	Timer and Timer Services: Real-time clocks and system clocks, programmable interval timers, timer interrupt service routines, model for implementing the soft-timer handling facility, timing wheels. I/O sub system: Basic I/O concepts, the I/O sub system; Memory management: Dynamic memory allocation, fixedsize memory management, blocking vs. Non-blocking memory functions, hardware memory management units.
UNIT IV	**TASKS COMMUNICATION AND SYNCHRONIZATION**
	Synchronization and Communication: Synchronization, communication, resource synchronization methods, common practical design patterns; common design problems: Resource classification, deadlocks, priority inversion

UNIT V	RTOS APPLICATION DOMAINS
	Comparison and study of RTOS: Vx works and COS, Case studies: RTOS for image processing, embedded RTOS for voice over IP, RTOS for fault tolerant applications, RTOS for control systems.

TEXTBOOKS

1. Andrew Troelsen,"Pro C and the .NET 4 Platform, Springer (India) Private Limited, New Delhi, India, 5th edition,2010.
2. David Chappell, "Understanding .NET – A Tutorial and Analysis", Addison Wesley, 2nd Edition, 2002.
3. Thamarai Selvi, R. Murugesan, A Textbook on C, Pearson Education, 1st Edition, 2003

REFERENCE BOOKS

1. Raymond J.A.Bhur, Donald L.Bailey, "An Introduction to Real Time Systems", PHI, 1st edition, 1999.
2. Wayne Wolf, "Computers as Components: Principles of Embedded Computing System Design", Kindle Publishers, 2nd edition, 2005.
3. Tanenbaum, "Modern Operating Systems", Pearson Edition, 3rd edition, 2007.

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1. https://www.jntumaterials.co.in
2. http://www.inf.ed.ac.uk/teaching/courses/es/PDFs/RTOS.pdf
3. https://nptel.ac.in/courses/106108101/pdf
4. http://wwww.iare.ac.in

E-TEXT BOOKS

1. http://www.bookzz.org/
2. http://www.jntubook.com
3. http://www.4shared.com/web/preview/pdf/BhrrT3m0

XVIII COURSE PLAN

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	

CONTENT DELIVERY (THEORY)			
1	History of operating systems	CO1	T1:1.1
2	Definition of RTOS	CO1	T1:1.2
3	Classification of real-time systems	CO1	T1:1.3
4	The scheduler, objects, services	CO1	T1:1.4
5	Key characteristics of RTOS	CO1	T1:1.5
6	Tasks: Defining a task, task states and	CO1	T1:1.6
7	Scheduling, typical task operations	CO1	T1:1.7
8	Typical task structure	CO1	T1:1.8
9	Examples of real-time operating systems	CO1	T1:1.9
10	Applications of Real-time operating system	CO1	T1:1.10
11	Clock-Based Event-Based Systems	CO1	T1:1.11
12	Interactive Systems	CO1	T1:1.12
13	Semaphores: Defining semaphores	CO2	T1:2.1
14	Typical semaphore operations	CO2	T1:2.2
15	Typical semaphore use	CO2	T1:2.3
16	Message Queues	CO2	T1:2.4
17	Semaphores: Defining semaphores	CO2	T1:2.5
18	Typical semaphore operations	CO3	T1:2.6
19	Typical semaphore use; Message Queues: C	CO3	T1:2.7
20	Defining message queues, message queue states	CO2	T1:2.8
21	Message queue content, message queue storage	CO3	T1:2.9
22	Typical message queue operations	CO2	T1:2.10
23	Typical message queue use other kernel objects	CO2	T1:2.11
24	Pipes, event registers, signals, condition variables	CO2	T1:2.12
25	Timer and Timer Services	CO3	T1:5.3
26	Real-time clocks and system clocks	CO3	T1:3.1
27	Programmable interval timers, timer interrupt service routines	CO3	T1:3.2
28	Model for implementing the soft-timer handling facility	CO3	T1:3.3
29	Timing wheels I/O sub system: Basic I/O concepts	CO3	T1:3.4
30	The I/O sub system; Memory management	CO3	T1:3.4.1
31	Dynamic memory allocation	CO3	T1:3.5
32	Blocking vs. Non-blocking memory functions	CO3	T1:3.6
33	Timer interrupt service routines	CO4	T1:3.7
34	hardware memory management units	CO4	T1:3.8
35	Fixed size memory management	CO4	T1:3.9
36	Timing wheels	CO4	T1:3.10
37	Synchronization and Communication	CO4	T1:4.1
38	Synchronization	CO5	T1:4.2
39	Inter-task communications	CO4	T1:4.3

40	Resource synchronization methods	CO4	T1:4.4
41	Soft real-time operating system	CO4	T1:4.5
42	Components of real time operating systems	CO4	T1:4.6
43	Task scheduling and execution in kernel models	CO4	T1:4.7
44	Semaphore token for the execution	CO4	T1:4.8
45	Tasks communication	CO5	T1:4.9
46	Task synchronization	CO5	T1:4.10
47	Programming embedded systems: RTOS - inter-thread	CO5	T1:4.11
48	Communications using Handshakes	CO5	T1:4.12
49	Comparison and study of RTOS	CO6	T1:5.2
50	Vx works and COS	CO6	T1:5.3
51	Case studies	CO6	T1:5.4
52	RTOS for image processing	CO6	T1:5.5
53	Embedded RTOS for voice over IP	CO6	T1:5.6
54	RTOS for fault tolerant applications	CO6	T1:5.7
55	RTOS for control systems	CO6	T1:5.8
56	Resource management and synchronization	CO6	T1:5.9
57	RTOS for Image Processing	CO6	T1:5.10
58	Embedded RTOS for voice over IP	CO6	T1:5.11
59	RTOS for fault Tolerant Applications	CO6	T1:5.12
60	RTOS for Control Systems	CO6	T1:5.13
DISCUSSION OF QUESTION BANK			
1	Real-Time Operating principles	CO1	T1:1.1-
2	Real time kernel objects	CO2	T1:2.1
3	RTOS design considerations	CO3	T1:3.1
4	Task communication and synchronization	CO5	T1:4.1
5	RTOS application domains	CO6	T1:5.1

Signature of Course Coordinator **HOD, ECE**

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Branch	**Electronics and Communication Engineering(ES)**				
Course Title	**ADVANCED COMPUTER ARCHITECTURE**				
Course Code	BESD08				
Program	M.Tech(EMBEDDED SYSTEMS)				
Semester	I				
Course Type	PROFESSIONAL ELECTIVE COURSES-II				
Regulation	IARE -MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr.S.China Venkateswarlu, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	Principles of digital electronics
B.Tech	-	-	Microprocessors and Microcontroller

II COURSE OVERVIEW:

This course intended to provide the structure, internal working and implementation of a computer system. The fundamentals of various functional units of computer, computer instructions, addressing modes, computer arithmetic and logic unit, registers, data transfer, memory and input output system. It focuses on analysis of computer performance and functioning in modern computers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
ADVANCED COMPUTER ARCHITECTURE	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted. CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Assignment / Quiz and 10 marks for Alternative Assessment Tool (AAT). Two CIE examinations are Compulsory and sum of the two exams, along with the scores obtained in the assignment / Quiz and AAT shall be considered for computing the final CIA of a student in a given course. Advance notification for the conduction of Assignment / Quiz / AAT is mandatory and the uploading and conduction is lies with the office of planning, monitoring and continuing studies.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIE-1**	**CIE-2**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Assignment / Quiz	5 Marks	5 Marks		10 Marks
Alternative Assessment Tool (AAT)	5 marks	5 marks		10 marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:
The assignments develop different skills and increase their knowledge base significantly. It provides the evidence for the faculty that the students have achieved the goals. It helps the faculty to evaluate the student's understanding of the course. Assignment will be evaluated for 5 marks. The assignment has to either handwritten / typed and uploaded to the Samvidha portal at the end of either CIE1 or CIE2, based on the questions provided by the course coordinator for that semester.

Quiz:
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2.
Alternative Assessment Tool (AAT):

In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. The AAT may include tech talk, case studies, seminars, term paper, open ended experiments, partial reproduction of research work, oral presentation of research work, developing a generic tool-box for problem solving, report based on participation in create-a-thon, makea-thon, code-a-thon, hack-a-thon conducted by reputed organizations / any other. etc.

VI COURSE OBJECTIVES:

The students will try to learn:

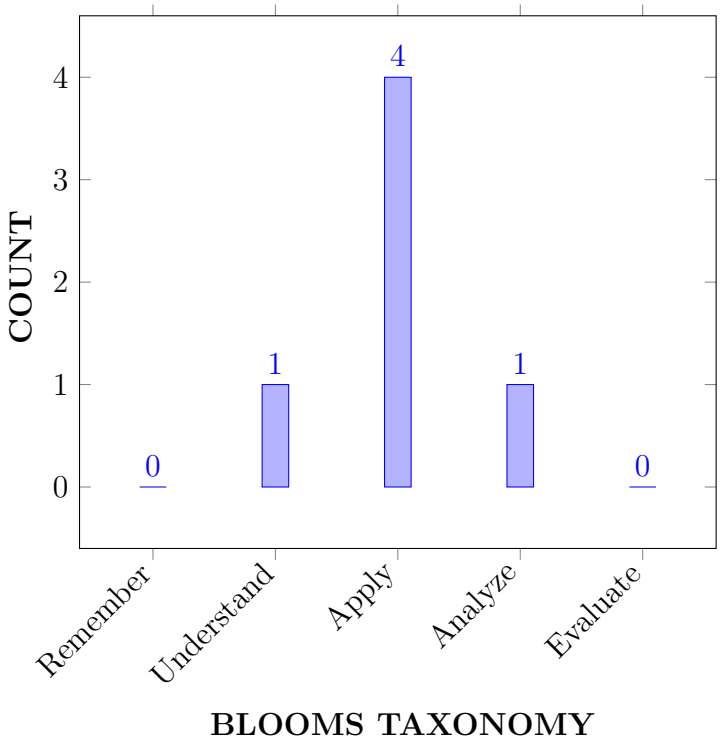
I	Understand the concept of micro-architectural design of processors.
II	Analyze performance improvement and power savings in current processors.
III	Study the different multiprocessor architectures and related issues
IV	Improve the knowledge on performance issues of memory and I/O systems.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the structure, characteristics of computer systems and understanding the components of computers.Interpret the various functional units for understanding the components of computers.	Understand
CO 2	**Demonstrate** the computer languages, machine, symbolic and assembly levels for understanding execution of program. for avoiding plagiarism in research	Analyze
CO 3	**Recall** the number system their representations and conversion for the usage of instructions in digital computers.	Apply
CO 4	**Demonstrate** the register transfer language, represent memory and Arithmetic/ Logic/ Shift operations for implementation of micro-operations.	Apply
CO 5	**Illustrate** the basics of hardwired and micro-programmed control of the CPU which generates the control signals to fetch and execute instructions	Apply
CO 6	**Compare** different types of addressing modes . for specifying the location of an operand	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems
PO 2	Write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	-	-	✓
CO 2	✓	-	-	-	-	✓
CO 3	✓	✓	-		-	-
CO 4	✓	✓	-		-	-
CO 5	✓	-	-	-		✓
CO 6	-	✓	-	-	-	-

X JUSTIFICATIONS FOR CO – PO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	**Describe** the steps involved in **problem identification for the research process** with **quality of work** and **demonstrate the solutions**	4
	PO 2	**Demonstrate and communicate** effectively in writing the **research problem** with **clarity** and **subject the knowledge while preparing report**	4
	PO 6	**Describe** the importance of **continuing education efforts through literature, personal development, meeting deadlines** and **producing solutions** in research study	4
CO 2	**PO 1**	**Explain** the methods for avoiding plagiarism in research work for improving the **quality of work, self driven** and **Independence** in research process	3
	PO 6	**Describe** the methods for avoiding plagiarism in research work by **continuing education efforts through literature, manage risk, meeting deadlines** and **producing solutions**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	**PO 1**	**Describe** the steps of **problem identification and implementation** in development of **independence, quality of work** by using research methodology	3
	PO 2	**Demonstrate and communicate effectively in writing** a proposed project with **clarity** and avoid the mistakes in terms of **grammar (writing)** to **subject knowledge while preparing report**	4
CO 4	**PO 1**	**Demonstrate the solutions** and **self driven, independence** in work for copyright and **quality of work** in document	4
	PO 2	**Demonstrate and communicate** effectively in Process of applying **presenting** Patent with clarity and **subject knowledge** of intellectual property management for claiming patent of invention	3
CO 5	**PO 1**	**Demonstrate the solutions** to attain the right of ownership and **independence and self driven** for scope of protection	3
	PO 6	**Continuing education efforts through literature, demonstrated ability to work well with a team, meeting deadlines and producing solutions** for licensing and transfer of technology in patent rights	4
CO 6	**PO 2**	**Demonstrate and communicate effectively** of the new Developments in IPR with considering **references** and **clarity** in **presentation**	4

Note: For Key Attributes refer **Annexure - I**

XI TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	4	4	-	-	-	4
CO 2	3	-	-	-	-	3
CO 3	3	4	-	-	-	-
CO 4	4	3	-	-	-	-
CO 5	3	-	-	-	-	4
CO 6	-	4	-	-	-	-

XII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	66.6	66.6	-	-	-	50
CO 2	50	-	-	-	-	37.5

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 3	50	66.6	-	-	-	-
CO 4	66.6	50	-	-	-	-
CO 5	50	-	-	-	-	50
CO 6	-	66.6	-	-	-	-

XIII COURSE ARTICULATION MATRIX (PO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0 ≤ C≤ 5% – No correlation
1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	-	-	-	2
CO 2	2	-	-	-	-	1
CO 3	2	3	-	-	-	-
CO 4	3	2	-	-	-	-
CO 5	2	-	-	-	-	2
CO 6	-	3	-	-	-	-
Total	12	11	-	-	-	5
Average	2.4	2.75	-	-	-	1.7

XIV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓	-	-	-	-

XV ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVI SYLLABUS:

MODULE I	FUNDAMENTALS OF COMPUTER DESIGN
	Fundamentals of computer design: Defining computer architecture, trends in technology, power in integrated circuits and cost, measuring and reporting performance, quantitative principles of computer design; Instruction set principles: Classifying ISA, design issues.

MODULE II	**INSTRUCTION-LEVELPARALLELISM**
	ILPconcepts: Pipelining over view, compiler techniques for exposing ILP; Dynamic branch prediction; Dynamic scheduling; Multiple instructions issue; Hardware based speculation; Static scheduling; Limitations of ILP; Case studies of contemporary microprocessors.
MODULE III	**DATA-LEVEL PARALLELISM**
	ILP software approach: Compiler techniques, static branch protection, VLIW approach, hardware support for more ILP at compile time, hardware verses software solutions. Multi vector and SIMD computers: Vector processing principles, multi svector multiprocessors, compound vector processing, SIMD computer organizations, the connection machine CM-5; Loop level parallelism.
MODULE IV	**MEMORY AND I/O**
	Introduction; cache performance: Reducing cache miss penalty and miss rate, Reducing hit time, Main memory and performance, Memory technology; Types of storage devices: Buses, RAID, Reliability, Availability and depend ability; Virtual memory; I/O performance measures: Designing an I/O system.
MODULE V	**MULTI PROCESSORS AND THREAD-LEVEL PARALLELISM**
	Introduction; Symmetric shared-memory architectures; Performance of Symmetric shared-memory architectures; Distributed shared memory and directory-based coherence; Basics of synchronization; Models of memory consistency; Multithreading.

TEXTBOOKS

1. 1. John L Hennessey and David A Patterson, — Computer Architecture A Quantitative Approach‖, Morgan Kaufmann/ Elsevier, 5 th Edition, 2013.
2. 2. John L Hennessey and David A Patterson, — Computer Architecture A Quantitative Approach ‖, Morgan Kaufmann/ Elsevier, 6 th Edition, 2017.
3. 2. John L Hennessey and David A Patterson, — Computer Architecture A Quantitative Approach ‖, Morgan Kaufmann/ Elsevier, 6 th Edition, 2017

REFERENCE BOOKS:

1. Kai Hwang, Faye Briggs, —Computer Architecture and Parallel Processing‖, McGraw-Hill International Edition, 2000.
2. Sima D, Fountain T. Kacsuk P, —Advanced Computer Architectures: A Design Spaces Approach‖, Addison Wesley, 2000.
3. David E. Culler, Jaswinder Pal Singh, Anoop Gupta, —Parallel Computer Architecture, A Hard ware/ Software Approach‖, Elsevier

WEB REFERENCES:

1. http://uni-site.ir/khuelec/wp-content/uploads/Computer-Architecture-A-Quantitative-Approach.pdf
2. https://doc.lagout.org/Computer

3. http://lecturesppt.blogspot.in/2010/03/advanced-computer-architecture.html

COURSE WEB PAGE:

https://lms.iare.ac.in/index?route=course/details&course_id=367

XVII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
0	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Introduction, Fundamentals of computer design	CO 1	T1:2.1
2	Defining computer architecture	CO 1	T1:2.1
3	trends in technology	CO 1	T1:2.3
4	power in integrated circuits and cost	CO 1	T1:2.3.1
5	measuring and reporting performance	CO 1	T1:7.2
6	quantitative principles of computer design	CO 1	T1:7.3
7	Instruction set principles:	CO 1	T1:7.4
8	Classifying ISA,	CO 1	T1:2.3
9	Design issues	CO 1	T1:7.4
10	ILP concepts	CO 1	T1:8.1
11	Pipelining over view	CO 1	T1:8.1.1
12	compiler techniques for exposing ILP	CO 1	T1:8.1.1
13	Dynamic branch prediction	CO 2	T1:8.2
14	Dynamic scheduling	CO 2	T1:8.2
15	Multiple instructions issue	CO 2	T1:8.2
16	Hardware based speculation	CO 2	T1:8.2
17	Static scheduling	CO 2	T1:8.2
18	Limitations of ILP;	CO 2	T1:8.2
19	Case studies of contemporary microprocessors	CO 2	T1:8.3
20	ILP software approach	CO 2	T1:8.4
21	Compiler techniques	CO 2	T1:8.5
22	static branch protection	CO 2	T1:8.6
23	VLIW approach	CO 2	T1:9.1
24	hardware support for more ILP at compile time	CO 2	T1:9.2
25	hardware verses software solutions	CO 2	T2:9.3.4
26	Multi vector and SIMD computers	CO 3	T2:7.1
27	ector processing principles	CO 3	T2:7.2
28	multi vector multiprocessors	CO 3	T2:7.3
29	compound vector processing	CO 3	T2:7.4
30	SIMD computer organizations	CO 4	T2:8.3
31	the connection machine CM-5	CO 4	T2:8.4
32	Loop level parallelism	CO 4	T3:8.5

33	Introduction	CO 4	T3:8.6
34	ache performance	CO 4	T3:8.6
35	Reducing cache miss penalty and miss rate	CO 4	T3:8.6
36	Reducing hit time	CO 4	T3:8.6
37	Main memory and performance	CO 5	T3:10.1-10.6
38	Memory technology	CO 5	T3:10.1-10.6
39	Types of storage device	CO 5	T3:11.10
40	Buses, RAID, Reliability	CO 5	T3:11.10
41	Availability and depend ability;	CO 5	T3:11.10
42	Virtual memory	CO 5	T3:11.14
43	/O performance measures	CO 5	T3:11.15
44	Designing an I/O system.	CO 5	T3:11.17
45	Introduction	CO 5	T3:11.17
46	- Symmetric shared-memory architectures	CO 5	T3:11.17
47	Performance of Symmetric shared-memory architectures	CO 5	T3:11.19
48	Distributed shared memory and directory-based coherence	CO 5	T3:11.21
49	Introduction on Multiprocessors and thread-Level parallelism	CO 5	T1:8.1-8.3; R2: 7.4-7.5
50	ymmetric shared	CO 5	T1-8.1-8.1.7
51	memory architectures	CO 5	T1-8.1-8.1.7
52	Performance of Symmetric shared	CO 6	T3:12.1
53	memory architectures	CO 6	T3:12.1
54	Distributed shared memory	CO 6	T3:12.1
55	irectory-based coherence	CO 6	T3:12.4
56	Basics of synchronization consistency	CO 6	T3:12.7
58	Models of memory consistency	CO 6	T3:12.10
59	Multithreading	CO 6	T3:12.13
60	Multithreading	CO 6	T3:12.15
DISCUSSION OF QUESTION BANK			
61	Module – I: Fundamentals of computer design	CO 1	T1:2.1-2.3
62	Module – II: Instruction-Level parallelism	CO 2	T1:8.2
63	Module – III: Data-Level parallelism	CO 3	T3:8.3
64	Module – IV: MEMORY AND I/O	CO 5	T3:10.1
65	Module – V: Multiprocessors and thread-Level parallelism	CO 6	T3:12.1-12.15

Signature of Course Coordinator **HOD,ECE**

ANNEXURE-I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
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COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**(ES)				
Course Title	**EMBEDDED SYSTEMS PROGRAMMING LABORATORY**				
Course Code	BESD11				
Program	M. Tech				
Semester	I				
Course Type	Core				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Mr.V.Prasannanjaneya Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
B.Tech	-	-	Embedded C	3
B.Tech	-	-	Operating Systems	3

II COURSE OVERVIEW:

This course outlines the design and implementation of embedded systems using suitable hardware and Keil Embedded C software tools. The instruction set, Embedded C programming for I/O and memory interfacing techniques are covered. The hands-on experience acquired by the student's during the course makes them to carry out processor/controller-based projects and extend their knowledge on the latest trends and technologies in the field of embedded system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Embedded System Programming Laboratory	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during

day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 1: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 2: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
2	2	2	2	2	10

Table 3: Programming based

Objective	Analysis4	Design	Conclusion	Viva voce	Total
2	2	2	2	2	10

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

VI COURSE OBJECTIVES:

The students will try to learn:

I	Use embedded C for reading data from port pins.
II	The interfacing of data I/O devices with microcontroller.
III	The serial communication and port RTOS on microcontroller

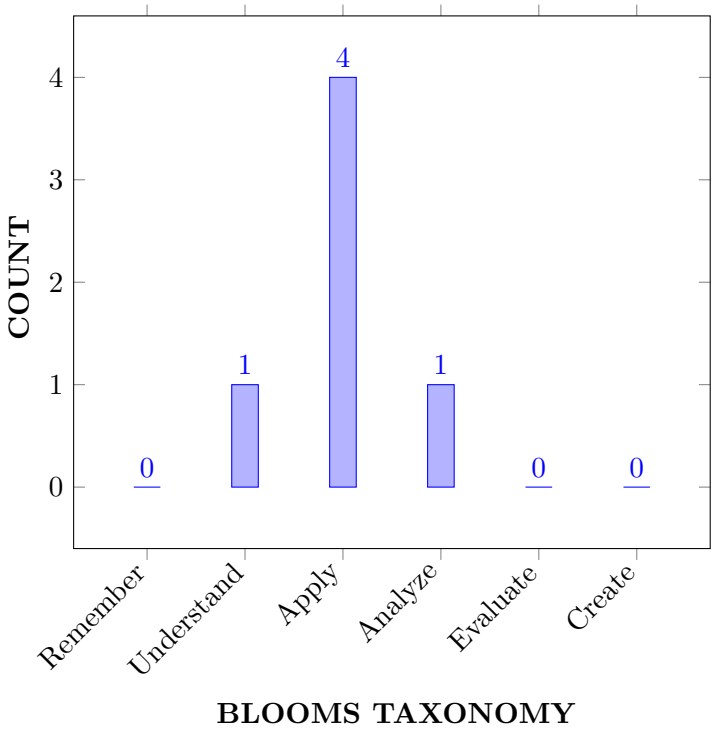
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use** of emulators and cross compilers for writing, compiling and running an embedded C language programs on training boards.	Apply
CO 2	**Develop** Embedded C language programs for accomplishing code to reading the data from ports, blinking the LED and interfacing of switch and buzzer and temperature sensors to the microcontrollers.	Analyze

CO 3	**Select** suitable RTOS of microcontroller and write Embedded C language program to run 2 to3 task simultaneously.	Apply
CO 4	**Choose** serial or parallel communication for transmitting the data between microcontroller and peripherals.	Apply
CO 5	**Summarize** the Analog to Digital and Digital to Analog converters with micro-controller for data conversion.	Understand
CO 6	**Build** an interface between microcontroller and peripheral stop provide solutions to the real world problems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	3	CIE/SEE/AAT
PO 2	Write and present a substantial technical report / document	3	CIE/SEE/AAT
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program	2	CIE/SEE/AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	3	CIE/SEE/AAT

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	✓	✓	✓	✓	-	-
CO2	✓	✓	-	✓	-	-
CO3	✓	✓	-	✓	-	-
CO4	✓	✓	✓	✓	-	-
CO5	✓	✓	✓	-	-	-
CO6	✓	✓	✓	-	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.

CO1	**PO 1**	Investigating various sensors and their applications in IoT involves research and **problem-solving**, requiring an in-depth understanding of how these sensors work. This will foster the ability to tackle **real-world IoT challenges** by applying **scientific principles and methodologies.**	**6**
	PO 2	After researching the sensor technologies and their applications, **documenting** and presenting findings requires the development of **technical writing and presentation skills**. This ensures clear communication of complex technical information to stakeholders, both in **written and oral** forms.	**4**
	PO 3	Mastery in understanding the different types of sensors used in IoT, along with their working principles and use cases, demonstrates a **higher level of expertise** in the field. The ability to apply this knowledge effectively shows a deep understanding beyond the basics, ensuring **comprehensive expertise** in the specialization.	**4**
	PO 4	Exploring sensor technologies in IoT applications equips learners to understand user needs and apply **scientific principles** to formulate and abstract real-world problems. It encourages **innovative thinking** for solution design, **experiment planning**, and effective use of resources like simulation tools, enabling deeper insight into embedded and robotic systems.	**5**
CO2	**PO 1**	Analyzing advanced sensors involves deep investigation into their evolving features and technological improvements. This develops the learner's ability to independently **research modern sensor capabilities** and apply them to solve accuracy and reliability issues in **real-world** industrial settings.	**6**
	PO 2	After researching the sensor technologies and their applications, **documenting and presenting** findings requires the development of technical **writing and presentation skills.** This ensures clear communication of complex technical information to stakeholders, both in **written and oral forms.**	**4**
	PO 4	Applies scientific principles to understand and integrate sensor technologies into embedded systems. Emphasizes **problem formulation and creative thinking** to develop **innovative**, sensor-based solutions. Involves managing the **design process and validating** system performance for effective use in IoT, healthcare, and communication domains.	**5**
CO3	**PO 1**	Understanding the architecture of wireless sensor systems involves identifying practical sensing **challenges and investigating** system modules to design effective solutions. Encourages independence, **self-driven** exploration, and the ability to implement and demonstrate functional wireless sensing setups with attention to quality and feasibility.	**5**

	PO 2	Demonstrating wireless sensor architecture involves not only technical understanding but also effective communication of the system's design, function, and integration. This requires clear **written documentation, proper referencing, and structured presentation**. Presenting insights from sensor system analysis reflects subject **knowledge, clarity, and communication skill**s—key to technical reporting.	**4**
	PO 4	Applying embedded system design concepts through problem **identification, experimentation, and solution development** using modern tools and methodologies. Encourages **innovation and scientific reasoning** to develop practical implementations for **real-world domains** such as IoT and communication. Reinforces the design, analysis, and validation of systems aligned with user needs and technological advancements.	**6**
CO4	**PO 1**	Understanding the operation of energy storage modules requires independence in conducting focused research. The ability to **identify problems** related to energy inefficiency and **implement solution**s in real-time scenarios reflects a **self-driven approach**. Demonstrating technical understanding in selecting and integrating modules also reflects the **quality of work** in addressing power reliability in wireless systems.	**6**
	PO 2	Exploring energy storage for wireless sensors involves effective **written communication and clarity in presentation** of technical concepts and configurations. Preparing structured documentation with **appropriate grammar and references** highlights the learner's subject knowledge and their ability to identify problems or opportunities in energy management for sensor networks.	**4**
	PO 3	Recognizing how energy storage systems enhance sensor reliability demonstrates knowledge and understanding of embedded applications. This includes **problem abstraction, use of creativity, and innovative design**. Mastery is shown through the design process, use of **modern tools, solution development, and validation** of the system's energy performance.	**5**
	PO 4	Energy storage integration into embedded systems showcases scientific principles, **problem-solving, and solution implementatio**n. Understanding user needs and applying **software tools or literature search methods** for optimal design reflects creativity and a deep grasp of IoT-based embedded applications. This competency supports **experimentation, evaluation, and project developmen**t in energy-aware system design.	**5**

CO5	**PO 1**	Understanding the NEST sensor ecosystem encourages independent investigation into energy-efficient technologies. It involves **problem identification and implementation** of intelligent home automation systems. The analysis and integration of such ecosystems reflect a **self-driven mindset and quality of work** in addressing real-world energy and automation challenges.	**6**
	PO 2	IDescribing the NEST ecosystem's working requires **clear written communication, structured presentation**, and proper referencing of smart home technologies. Presenting its functionality and benefits showcases clarity, strong subject knowledge, and an ability to identify opportunities in energy-efficient design.	**3**
	PO 3	Explaining the NEST sensor system showcases knowledge and understanding of intelligent embedded systems in real-time applications. It involves **problem abstraction, innovative product design, and the use of modern tools for solution development, evaluation**, and result validation—all demonstrating a higher level of mastery in the domain of smart technologie	**5**
CO6	**PO 1**	Understanding how hardware components interact requires identifying implementation-level challenges and exploring how to resolve them using platform-specific strategies. This develops **problem identification, quality of work, and self-driven investigation** needed in embedded system tasks.	**5**
	PO 2	Explaining communication protocols, circuit integration, and hardware programming principles strengthens the ability to **document processes, clarify design logic, and effectively present technical solutions** in embedded applications.	**4**
	PO 3	Mastery of embedded hardware interaction indicates deep knowledge, **innovative thinking, and the ability to design and implement hardware-software systems** that go beyond basic undergraduate expectations.	**5**

Note: For Key Attributes refer **Annexure - I**

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	6	4	4	5	-	-
CO 2	6	4	-	5	-	-
CO 3	5	4	-	6	-	-
CO 4	6	4	5	5	-	-
CO 5	6	3	5	-	-	-
CO 6	5	4	5	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	100	66.6	44.4	50	-	-
CO 2	100	66.6	-	50	-	-
CO 3	83.3	66.6	-	60	-	-
CO 4	100	66.6	55.5	60	-	-
CO 5	100	50	55.5	-	-	-
CO 6	83.33	66.66	55.5	-	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.
0 - 0 ≤ C≤ 5% – No correlation
1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	2	2	-	-
CO 2	3	3	-	2	-	-
CO 3	3	3	-	3	-	-
CO 4	3	3	2	3	-	-
CO 5	3	2	2	-	-	-
CO 6	3	3	2	-	-	-
TOTAL	**18**	**17**	**8**	**10**	**-**	**-**
AVERAGE	**3**	**2.8**	**2**	**2.5**	**-**	**-**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
Quiz	-	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	✓	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVII SYLLABUS:

WEEK I	**LED BLINKING**
	Program to toggle all the bits of port P1continuouslywith250msdelay.
WEEK II	**INTERFACING OF SWITCH AND BUZZER**
	Program to interface a switch and a buzzer to two different pins of a port such that the buzzer should sound as long as the switch is pressed.
WEEK III	**INTERFACING OF LCD**
	Program to interface LCD data pins to port P1 and display a message on it.
WEEK IV	**INTERFACING SEVEN SEGMENT DISPLAY**
	Program to interface seven segment display.
WEEK V	**INTERFACING OF KEYPAD**
	Program to interface keypad. Whenever a key is pressed, it should be displayed on LCD.
WEEK VI	**SERIAL COMMUNICATION**
	Program to transmit message from microcontroller to PC serially using RS232. Program to receive a message from PC to microcontroller serially using RS232
WEEK VII	**INTERFACING OF STEPPER MOTOR**
	Program to interface Stepper Motor to rotate the motor in clockwise and anti-clock wise directions program to toggle all the bits of port P1continuouslywith250msdelay.
WEEK VIII	**INTERFACING TEMPERATURE SENSOR**
	Program to read data from temperature sensor and display the temperature value.
WEEK IX	**PORTING OF RTOS**
	Port RTOS on to 89V51 Microcontroller and verify. Run 2 to 3 tasks simultaneously on 89V51 SDK. Use LCD interface, LED interface, Serial communication.
WEEK X	**INTERFACING OF ADC**
	Program to convert analog signal into digital (ADC).
WEEK XI	**INTERFACING OF DAC**
	Program to convert Digital into Analog (DAC).
WEEK XII	**INTERFACING OF ELEVATOR**
	Program to interface Elevator.
WEEK XIII	**INTERFACING OF SERVO MOTOR**
	Program to interfacing of servo motor.
WEEK XIV	**INTERFACING OF LCD DISPLAY**
	Program to interfacing of LCD displays

REFERENCE BOOKS:

1. Michael J. Pont, “Embedded C”, Pearson Education, 2nd Edition, 2008.
2. Nigel Gardner, “The Microchip PIC in CCS C”. Ccs Inc, 2nd Revision Edition, 2002.

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	LED BLINKING. Program to toggle all the bits of port P1 continuously with 250ms delay.	CO 1	T1:1.1,1.2
2	INTERFACING OF SWITCH AND BUZZER Program to interface a switch and a buzzer to two different pins of a port such that the buzzer should sound as long as the switch is pressed.	CO 2	T1:1.3,1.6
3	INTERFACING OF LCD Program to interface LCD data pins to port P1 and display a message on it.	CO 3	T1:9,1.12
4	INTERFACING SEVEN SEGMENT DISPLAY Program to interface seven segment display.	CO 4	T1:17.1,1.23
5	INTERFACING OF KEYPAD Program to interface keypad. Whenever a key is pressed, it should be displayed on LCD.	CO 4	T2:11.1,1.8
6	SERIAL COMMUNICATION Program to transmit message from microcontroller to PC serially using RS232. Program to receive a message from PC to microcontroller serially using RS232	CO4	T2:10.1,10.4
7	INTERFACING OF STEPPER MOTOR Program to interface Stepper Motor to rotate the motor in clockwise and anti-clock wise directions program to toggle all the bits of port P1 continuously with 250ms delay.	CO 4	T2:11.2-11.4
8	INTERFACING TEMPERATURE SENSOR Program to read data from temperature sensor and display the temperature value.	CO 5	T2:9.1,1.6
9	PORTING OF RTOS Port RTOS on to 89V51 Microcontroller and verify. Run 2 to 3 tasks simultaneously on 89V51 SDK. Use LCD interface, LED interface, Serial communication.	CO 5	T2:10.2-11.4
10	INTERFACING OF ADC Program to convert analog signal into digital (ADC).	CO 5	T2:9.2-11.4
11	INTERFACING OF DAC Program to convert Digital into Analog (DAC).	CO 6	T1:12,1.9
12	INTERFACING OF ELEVATOR Program to interface Elevator.	CO 6	T2:1.1,1.5
13	INTERFACING OF SERVO MOTOR Program to interfacing of servo motor.	CO 6	T2:8.2-11.4
14	INTERFACING OF LCD DISPLAY Program to interfacing of LCD displays	CO 5	T2:13.2-11.4

Signature of Course Coordinator

Mr.V.Prasannanjaneya Reddy, Assistant Professor

HOD, ECE

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
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PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	7
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1. Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	8

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
COURSE DESCRIPTION

Branch	**Electronics and Communication Engineering(ES)**				
Course Title	**MICROCONTROLLERS AND PROGRAMMABLE DSP LAB**				
Course Code	BESD12				
Program	M.Tech				
Semester	I				
Course Type	Core				
Regulation	MT-23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Ms. C V P Supradeepthi, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	Digital Signal Processing
B.Tech	-	-	Microprocessors and Microcontrollers

II COURSE OVERVIEW:

This course provides knowledge of basics of DSP processors and embedded C programming language. It covers the concepts like blinking an LED with software delay, system clock real time alteration using the PLL modules and controlling an LED using switch by polling method. Through laboratory experiments, students are provided learning experiences that enable them to provide in depth knowledge about embedded and DSP processors.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Microcontrollers and programmable DSP laboratory	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 1: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 2: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
2	2	2	2	2	10

Table 3: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
2	2	2	2	2	10

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

VI COURSE OBJECTIVES:

The students will try to learn:

I	Demonstrate Keil IDE tool for development of Embedded system.
II	The Program the interfacing of various devices with ARM using Embedded C.
III	Implementation of digital signal processing algorithms in MATLAB and C.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** Cortex-M3 development board write a assembly language program for LED display in various applications	Apply
CO 2	**Analyze** the various sleep modes by putting core in sleep and deep sleep modes using GNU tool chain	Analyze
CO 3	**Develop** an embedded C program for Temperature indication on an RGB LED and Verify the output in the Cortex-M3 kit	Apply
CO 4	**Build** an assembly code and C code to compute Euclidian distance between any two Points	Apply
CO 5	**Examine** various filters in C to enhance the features of given input sequence or signal	Apply
CO 6	**Design** an assembly and C code for convolution Operation using code composer studio (CCS).	Create

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	2	CIE/SEE/AAT
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program	2	CIE/SEE/AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	3	CIE/SEE/AAT

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	✓	-	✓	✓	-	-
CO2	✓	-	-	-	-	-
CO3	✓	-	✓	✓	-	-
CO4	✓	-	-	✓	-	-
CO5	✓	-	-	✓	-	-
CO6	✓	-	✓	✓	-	✓

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Out-comes	PO'S	Justification for mapping (Students will be able to)	No. of Key competen-cies matched.
CO1	**PO 1**	**Understand** the concepts of ARM Cortex-M3 processor by applying **Scientific principles and methodology, Use creativity** to establish architecture , identify **Problem formulation** for interfacing **problems**, **Implement** different applications by using arm processor.	**6**
	PO 3	Analyze the given **problem statement** and **formulate** the kernel, and other components in embedded systems and **use creativity** to establish **innovative solutions** for embedded system , **Interpret** the result on various applications	**4**
	PO 4	**Develop** ARM Cortex-M3 processor for various **Problems** in pre processors , **implement** advanced arm processor for real time applications	**3**
CO2	**PO 4**	Illustrate the concepts (knowledge) of task scheduling types for Soft real-time operating system and Hard Real-Time operating systems by using mathematics, science, engineering fundamentals to the solution of complex engineering problems	**6**
CO3	**PO 1**	Illustrate components of real time operating systems (knowledge) to integrate the software and hardware components (mathematical model) the design of reliable embedded system by applying the principles of mathematical model and science	**5**
	PO 3	Construct the high level of integration in embedded applications using LPC 17XX Microcontroller	**4**
	PO 4	Independently carry out research / investigation and development work to solve practical problems.	**3**
CO4	**PO 1**	Analyze (problem statement) finite state machine by applying solutions for complex engineering problems and design system components.	**6**
CO5	**PO 1**	Create (Engineering knowledge) semaphore token for the execution of one or more threads in mutual exclusion by applying the principles of mathematics, science.	**5**
	PO 4	Identify the given problem statement and solve it using synchronization or mutual exclusion by applying mathematical properties.	**3**
CO6	**PO 1**	Understand (knowledge) asynchronous communications protocol in operating systems by applying its mathematical properties.	**6**
	PO 3	Analyze the given **problem statement** and **formulate** the kernel, and other components in embedded systems and **use creativity** to establish **innovative solutions** for embedded system , **Interpret** the result on various applications	**4**

	PO 4	Understand (knowledge) asynchronous communications protocol in operating systems by applying its mathematical properties.	**3**

Note: For Key Attributes refer **Annexure - I**

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

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COURSE OUTCOMES	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	3	-	4	6	-	-
CO 2	-	-	-	6	-	-
CO 3	3	-	4	5	-	-
CO 4	-	-	-	6	-	-
CO 5	3	-	-	5	-	-
CO 6	3	-	4	5	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	50	-	44.4	60	-	-
CO 2	-	-	-	60	-	-
CO 3	50	-	44.4	50	-	-
CO 4	-	-	-	60	-	-
CO 5	50	-	-	50	-	-
CO 6	50	-	44.4	50	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	2	3	-	-
CO 2	-	-	-	3	-	-
CO 3	2	-	2	2	-	-
CO 4	-	-	-	3	-	-
CO 5	2	-	-	2	-	-
CO 6	2	-	2	2	-	-
TOTAL	**8**	**-**	**6**	**15**	**-**	**-**
AVERAGE	**2**	**-**	**2**	**2.5**	**-**	**-**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	-	Tech - Talk	-	Certification	-
Term Paper	✓	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
-	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVII SYLLABUS:

Part A) Experiments to be carried out on Cortex-M3 development boards and using GNU tool chain	
WEEK I	**Blink an LED with software delay, delay generated using the SysTick timer.**
WEEK II	**System clock real time alteration using the PLL modules.**
WEEK III	**Control intensity of an LED using PWM implemented in software and hardware**
WEEK IV	**Control an LED using switch by polling method, by interrupt method and flash the LED once.**
WEEK V	**UART Echo Test.**
WEEK VI	**Take analog readings on rotation of rotary potentiometer connected to an ADC channel**
WEEK VII	**Temperature indication on an RGB LED**
WEEK VIII	**Mimic light intensity sensed by the light sensor by varying the blinking rate of an LED.**
WEEK IX	**Evaluate the various sleep modes by putting core in sleep and deep sleep modes.**

WEEK X	**System reset using watchdog timer in case something goes wrong.**
WEEK XI	**Sample sound using a microphone and display sound levels on LEDs.**
Part B) Experiments to be carried out on DSP C6713 evaluation kits and using (CCS)	
WEEK XII	**To develop an assembly code and C code to compute Euclidian distance between any two points**
WEEK XIII	**To develop assembly code and study the impact of parallel, serial and mixed execution.**
WEEK XIV	**To develop assembly and C code for implementation of convolution operation.**
WEEK XV	**To design and implement filters in C to enhance the features of given input sequence/signal**

TEXTBOOKS

1. Joseph Yiu, "The Definitive Guide to ARM Cortex-M3", Elsevier, 3rd Edition, 2014.
2. Venkatramani B, Bhaskar M, —Digital Signal Processors: Architecture, Programming and Applications", TMH, 2nd Edition, 2011.

REFERENCE BOOKS:

1. Sloss Andrew N, Symes Dominic, Wright Chris, —"ARM System Developer's Guide: Designing and Optimizing", Morgan Kaufman Publications
2. Steve furber, —"ARMSystem-on-ChipArchitecture", Pearson Education.
3. Frank Vahid and Tony Givargis, —"Embedded System Design", Wiley Publications

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Blink an LED with software delay, delay generated using the SysTick timer.	CO 1	T1: 1.1.5
2	System clock real time alteration using the PLL modules.	CO 1	T1: 3.2-3.5
3	Control intensity of an LED using PWM implemented in software and hardware	CO 2	T1: 3.5-3.7
4	Control an LED using switch by polling method, by interrupt method and flash the LED once.	CO 5	T1: 4.1-4.2
5	UART Echo Test.	CO 2	T1: 4.2-4.3
6	Take analog readings on rotation of rotary potentiometer connected to an ADC channel	CO 2	T1: 4.3-4.4
7	Temperature indication on an RGB LED	CO 2	T1:5.1-5.2
8	Mimic light intensity sensed by the light sensor by varying the blinking rate of an LED.	CO 3	T1:5.2,5.5

9	Evaluate the various sleep modes by putting core in sleep and deep sleep modes.	CO 3	T1: 6.1-6.2
10	System reset using watchdog timer in case something goes wrong.	CO 3	T1: 6.1-6.2
11	To develop an assembly code and C code to compute Euclidian distance between any two points	CO 4	T1: 7.1-7.2
12	To develop assembly code and study the impact of parallel, serial and mixed execution.	CO 6	T1: 7.1-7.2
13	To develop assembly and C code for implementation of convolution operation.	CO 4	T1: 7.4-7.5
14	To design and implement filters in C to enhance the features of given input sequence/signal	CO 5	T1: 7.4-7.5
15	To develop an assembly code and C code to compute Euclidian distance between any two points	CO 6	T2: 7.6-8.1

Course Coordinator **HOD,ECE**

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Branch	**Electronics and Communication Engineering(ES)**				
Course Title	**Research Methodology and IPR**				
Course Code	BHSD01				
Program	M.Tech				
Semester	I				
Course Type	Core				
Regulation	IARE - MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Mr.U Soma Naidu, Assistant Professor				

I COURSE OVERVIEW:

This course provides the basic concepts on research methodology and intellectual property rights. This course emphasis on sampling techniques, data collection, writing Reports, Projects, Dissertations, thesis and articles for publication in academic journals, avail the intellectual property rights of the inventors or owners for their assets like patents on innovative design, copy rights on literary and artistic works, trademark on goods & services and geographical indications on products famous for specific geographical areas.This course makes use of the potential future economic benefits to the intellectual property owner or authorized user.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
M.Tech	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Research Methodology and IPR	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks.

There could be a maximum of two / three sub divisions in a question.
The emphasis on the questions is broadly based on the following criteria:

50%	To test the objectiveness of the concept
30 %	To test the analytical skill of the concept
20 %	To test the application skill of the concept

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted. CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Assignment / Quiz and 10 marks for Alternative Assessment Tool (AAT). Two CIE examinations are Compulsory and sum of the two exams, along with the scores obtained in the assignment / Quiz and AAT shall be considered for computing the final CIA of a student in a given course. Advance notification for the conduction of Assignment / Quiz / AAT is mandatory and the uploading and conduction is lies with the office of planning, monitoring and continuing studies.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Assignment / Quiz	05 Marks	05 Marks		10 Marks
Alternative Assessment Tool (AAT)	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment
The assignments develop different skills and increase their knowledge base significantly. It provides the evidence for the faculty that the students have achieved the goals. It helps the faculty to evaluate the student's understanding of the course. Assignment will be evaluated for 5 marks. The assignment has to either handwritten / typed and uploaded to the Samvidha portal at the end of either CIE1 or CIE2, based on the questions provided by the course coordinator for that semester.

Quiz
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2.

Alternative Assessment Tool (AAT)
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. The AAT may include tech talk, case studies, seminars, term paper, open ended experiments, partial reproduction of research work, oral presentation of research work, developing a generic tool-box for problem solving, report based on participation in create-a-thon, makea-thon, code-a-thon, hack-a-thon conducted by reputed organizations / any other. etc.

VI COURSE OBJECTIVES:

The students will try to learn:

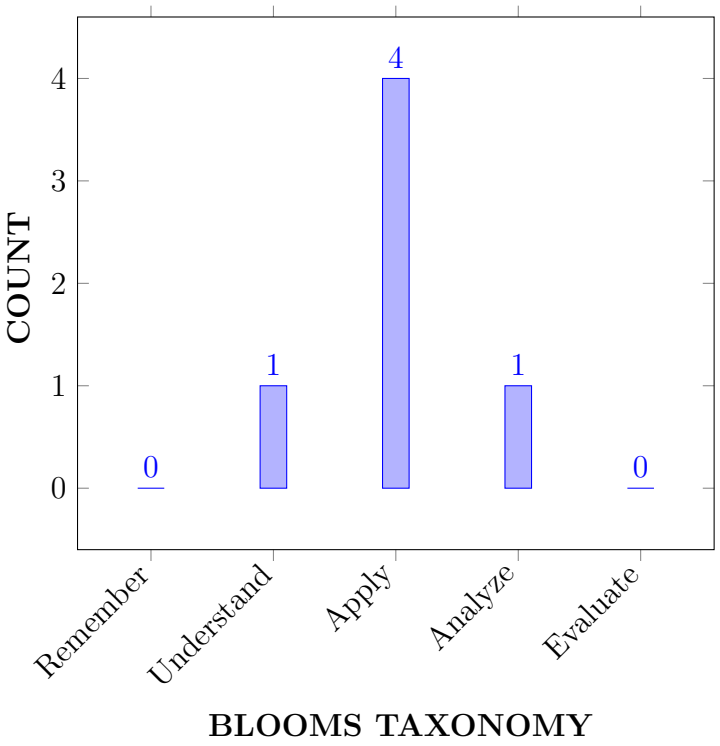
I	The knowledge on sources of research problem, data collection, analysis, and interpretation.
II	The importance of effective technical writing and analysis plagiarism.
III	The new developments in the law of intellectual property rights in order to bring progressive changes towards a free market society.

VII COURSE OUTCOMES:

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

CO 1	**Interpret** the technique of determining a research problem for a crucial part of the research study	Understand
CO 2	**Examine** the way of methods for avoiding plagiarism in research	Analyze
CO 3	**Apply** the feasibility and practicality of research methodology for a proposed project	Apply
CO 4	**Make use of** the legal procedure and document for claiming patent of invention.	Apply
CO 5	**Identify** different types of intellectual properties, the right of ownership, scope of protection to create and extract value from IP	Apply
CO 6	**Defend** the intellectual property rights throughout the world with the involvement of World Intellectual Property Organization	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems
PO 2	Write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems	2	CIE/SEE/AAT
PO 2	Write and present a substantial technical report / document.	2	CIE/SEE/AAT
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	1	CIE/SEE/AAT

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	-	-	✓
CO 2	✓	-	-	-	-	✓
CO 3	✓	✓	-		-	-
CO 4	✓	✓	-		-	-
CO 5	✓	-	-	-		✓
CO 6	-	✓	-	-	-	-

XI JUSTIFICATIONS FOR CO – PO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	**Describe** the steps involved in **problem identification for the research process** with **quality of work** and **demonstrate the solutions**	4
	PO 2	**Demonstrate and communicate** effectively in writing the **research problem** with **clarity** and **subject the knowledge while preparing report**	4
	PO 6	**Describe** the importance of **continuing education efforts through literature, personal development, meeting deadlines** and **producing solutions** in research study	4
CO 2	**PO 1**	**Explain** the methods for avoiding plagiarism in research work for improving the **quality of work, self driven** and **Independence** in research process	3
	PO 6	**Describe** the methods for avoiding plagiarism in research work by **continuing education efforts through literature, manage risk, meeting deadlines** and **producing solutions**	3
CO 3	**PO 1**	**Describe** the steps of **problem identification and implementation** in development of **independence, quality of work** by using research methodology	3
	PO 2	**Demonstrate and communicate effectively in writing** a proposed project with **clarity** and avoid the mistakes in terms of **grammar (writing)** to **subject knowledge while preparing report**	4
CO 4	**PO 1**	**Demonstrate the solutions** and **self driven, independence** in work for copyright and **quality of work** in document	4
	PO 2	**Demonstrate and communicate** effectively in Process of applying **presenting** Patent with clarity and **subject knowledge** of intellectual property management for claiming patent of invention	3
CO 5	**PO 1**	**Demonstrate the solutions** to attain the right of ownership and **independence and self driven** for scope of protection	3
	PO 6	**Continuing education efforts through literature, demonstrated ability to work well with a team, meeting deadlines and producing solutions** for licensing and transfer of technology in patent rights	4
CO 6	**PO 2**	**Demonstrate and communicate effectively** of the new Developments in IPR with considering **references** and **clarity** in **presentation**	4

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	4	4	-	-	-	4
CO 2	3	-	-	-	-	3
CO 3	3	4	-	-	-	-
CO 4	4	3	-	-	-	-
CO 5	3	-	-	-	-	4
CO 6	-	4	-	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	66.6	66.6	-	-	-	50
CO 2	50	-	-	-	-	37.5
CO 3	50	66.6	-	-	-	-
CO 4	66.6	50	-	-	-	-
CO 5	50	-	-	-	-	50
CO 6	-	66.6	-	-	-	-

XIV COURSE ARTICULATION MATRIX (PO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	-	-	-	2
CO 2	2	-	-	-	-	1
CO 3	2	3	-	-	-	-
CO 4	3	2	-	-	-	-
CO 5	2	-	-	-	-	2
CO 6	-	3	-	-	-	-
Total	12	11	-	-	-	5
Average	2.4	2.75	-	-	-	1.7

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
AAT	✓	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓				

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
-	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVII SYLLABUS:

MODULE I	**INTRODUCTION**
	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations
MODULE II	**RESEARCH ETHICS**
	Effective literature studies approaches, analysis Plagiarism, Research ethics.
MODULE III	**RESEARCH PROPOSAL**
	Effective technical writing, how to write report, Paper Developing a Research Proposal. Format of research proposal, a presentation and assessment by a review committee
MODULE IV	**PATENTING**
	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT
MODULE V	**PATENT RIGHTS**
	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs

TEXTBOOKS

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science and engineering students".
2. C R Kothari, "Research Methodology: Methods and techniques", New age international limited publishers, 1990 .
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"

REFERENCE BOOKS:

1. Halbert, "Resisting Intellectual Property", Taylor and Francis Ltd , 2007.
2. Mayall , "Industrial Design", McGraw Hill, 1992.
3. Niebel , "Product Design", McGraw Hill, 1974.

WEB REFERENCES:

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley Age", 2016 , " Intellectual Property in New Technological Age", 2016
2. T. Ramappa, "Intellectual Property Rights Under WTO" S. Chand 2008
3. Peter-Tobias stoll, Jan busche, Katrianarend- WTO- Trade –related aspects of IPR-Library of Congress

COURSE WEB PAGE:

https://lms.iare.ac.in/index?route=course/details&course_id=367

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
0	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
	CONTENT DELIVERY (THEORY)		
1	Introduction, Definition, types of research	CO 1	T1:2.1
2	Meaning of research problem	CO 1	T1:2.1
3	Sources of research problem	CO 1	T1:2.3
4	Criteria characteristics of good research problem	CO 1	T1:2.3.1
5	Research process	CO 1	T1:7.2
6	Research design	CO 1	T1:7.3
7	Errors in selecting a research problem	CO 1	T1:7.4
8	Scope and objectives of research problem	CO 1	T1:2.3
9	Approaches of investigation of solutions for research problem	CO 1	T1:7.4
10	Data collection	CO 1	T1:8.1
11	Analysis and interpretation of data	CO 1	T1:8.1.1
12	Necessary instrumentation's	CO 1	T1:8.1.1
13	Effective literature studies approaches	CO 2	T1:8.2
14	Literature	CO 2	T1:8.2
15	Literature review	CO 2	T1:8.2
16	Literature review techniques	CO 2	T1:8.2
17	Literature studies	CO 2	T1:8.2
18	Introduction to ethics, Importance of ethics	CO 2	T1:8.2
19	Ethical issues in conducting research	CO 2	T1:8.3
20	Principles of research ethics	CO 2	T1:8.4

21	Analysis	CO 2	T1:8.5
22	Plagiarism- types of plagiarism	CO 2	T1:8.6
23	Tips to avoid plagiarism	CO 2	T1:9.1
24	Other ethical issues	CO 2	T1:9.2, 9.3
25	Interpretation, Interpretation Techniques and precautions	CO 2	T2:9.3.4
26	Writing of report and steps involved	CO 3	T2:7.1
27	Layout of research report	CO 3	T2:7.2
28	Types of reports	CO 3	T2:7.3
29	Paper developing a research proposal	CO 3	T2:7.4
30	Format of research proposal	CO 4	T2:8.3
31	Presentation of report	CO 4	T2:8.4
32	Summary of findings	CO 4	T3:8.5
33	Assessment by review committee	CO 4	T3:8.6
34	Technical appendixes	CO 4	T3:8.6
35	Logical analysis of the subject matter	CO 4	T3:8.6
36	Statement of findings and recommendations	CO 4	T3:8.6
37	Introduction, Nature of Intellectual Property	CO 5	T3:10.1-10.6
38	Types of intellectual Property rights	CO 5	T3:10.1-10.6
39	Patents	CO 5	T3:11.10
40	Designs	CO 5	T3:11.10
41	Trademarks and copyrights: Definition, classification of trademarks	CO 5	T3:11.10
42	Process of Patenting and Development	CO 5	T3:11.14
43	Technical research, innovation, patenting	CO 5	T3:11.15
44	Developments in patenting	CO 5	T3:11.17
45	Patent Trademark Organization	CO 5	T3:11.17
46	International Organization, Agencies and Treaties	CO 5	T3:11.17
47	International scenario, international cooperation on Intellectual property	CO 5	T3:11.19
48	Procedure for grant of patents	CO 5	T3:11.21
49	procedure of copyright	CO 5	T1:8.1-8.3; R2: 7.4-7.5
50	Patenting under PCT, Provisional patent application	CO 5	T1-8.1-8.1.7
51	Patent protection for the invention	CO 5	T1-8.1-8.1.7
52	Patent Rights	CO 6	T3:12.1
53	Scope of Patent Rights	CO 6	T3:12.1
54	Licensing and transfer of technology	CO 6	T3:12.1
55	Patent information and databases	CO 6	T3:12.4
56	Geographical Indications	CO 6	T3:12.4

57	New Developments in IPR: Administration of Patent System	CO 6	T3:12.7
58	New developments in IPR, IPR of Biological Systems and Computer Software etc	CO 6	T3:12.10
59	Traditional knowledge Case Studies	CO 6	T3:12.13
60	IPR and IITs.	CO 6	T3:12.15
DISCUSSION OF QUESTION BANK			
61	Module – I: Research problem	CO 1	T1:2.1-2.3
62	Module – II: Research ethics	CO 2	T1:8.2
63	Module – III: Research proposal	CO 3, CO 4	T3:8.3; R2: 7.4-7.5
64	Module – IV: Patenting	CO 5	T3:10.1-10.6
65	Module – V: Patent rights	CO 6	T3:12.1-12.15

Signature of Course Coordinator **HOD,ECE**
U.Soma Naidu ,Assistant Professor

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering(ES)**				
Course Title	**Internet Of Things and Applications**				
Course Code	BESD13				
Program	M.Tech				
Semester	II				
Course Type	Core				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms. Ajitha G, Assistant Professor				

I COURSE OVERVIEW:

This course will explore the fascinating world of IoT and delve into its various applications that are shaping the future of technology and connectivity. The course is designed to provide a solid foundation in both the theoretical and practical aspects of IoT, equipping you with the knowledge and skills to understand, design, and implement IoT solutions across diverse industries.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	Embedded System Design and Developement
M.Tech	-	-	Embedded System Programming

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Internet Of Things and Applications	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted. CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Assignment / Quiz and 10 marks for Alternative Assessment Tool (AAT). Two CIE examinations are Compulsory and sum of the two exams, along with the scores obtained in the assignment / Quiz and AAT shall be considered for computing the final CIA of a student in a given course. Advance notification for the conduction of Assignment / Quiz / AAT is mandatory and the uploading and conduction is lies with the office of planning, monitoring and continuing studies.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIE-1	CIE-2	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Assignment / Quiz	5 Marks	5 Marks		10 Marks
Alternative Assessment Tool (AAT)	5 marks	5 marks		10 marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:

The assignments develop different skills and increase their knowledge base significantly. It provides the evidence for the faculty that the students have achieved the goals. It helps the faculty to evaluate the student's understanding of the course. Assignment will be evaluated for 5 marks. The assignment has to either handwritten / typed and uploaded to the Samvidha portal at the end of either CIE1 or CIE2, based on the questions provided by the course coordinator for that semester.

Quiz:

It is online proctor based online examination conducted either at the end of the CIE1 or CIE2.

Alternative Assessment Tool (AAT):
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. The AAT may include tech talk, case studies, seminars, term paper, open ended experiments, partial reproduction of research work, oral presentation of research work, developing a generic tool-box for problem solving, report based on participation in create-a-thon, makea-thon, code-a-thon, hack-a-thon conducted by reputed organizations / any other. etc.

VI COURSE OBJECTIVES:

The students will try to learn:

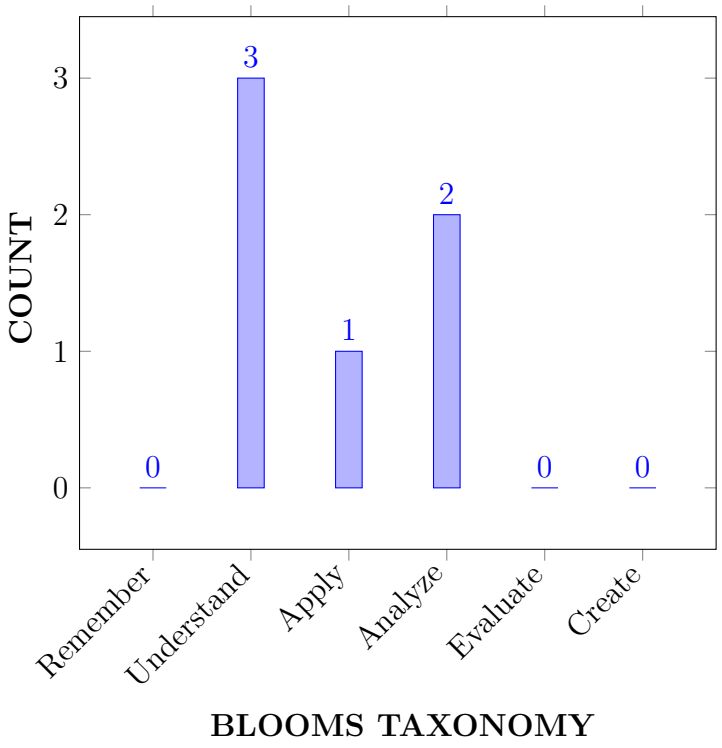
I	Build IoT Prototypes, design sensor networks, and work with IoT platforms to gain practical experience.
II	Explore the various wireless communication technologies that enable IoT devices to connect and communicate, such as Wi-Fi, Bluetooth, Zigbee, LoRa WAN, and cellular networks.
III	Delve into different types of sensors used in IoT applications, including environmental sensors, motion sensors, proximity sensors, and more.
IV	Engage in hands-on projects that allow to apply knowledge in real-world scenarios

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Relate** different types of sensors used in IoT applications, including their working principles and real - world use cases.	Understand
CO 2	**Analyze** advanced generation sensors,including their features, improvements over earlier technologies, and the role they play in enhancing data accuracy and precision in industrial applications.	Analyze
CO 3	**Demonstrate** the components and architecture of wireless sensor systems, including their fundamental structure and the interplay of various modules in achieving wireless sensing capabilities.	understand
CO 4	**Identify** the role and characteristics of energy storage modules in wireless sensor systems, and how they enable reliable and continuous sensor operation by storing and managing energy from various sources.	Apply
CO 5	**Explain** the NEST sensor ecosystem, including its characteristics, functionalities, and its contribution to creating smart and energy-efficient homes.	Understand
CO 6	**Develop** the ability to interact with hardware components using the chosen platform, including communication protocols, wiring, and programming	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	3	CIE/SEE/AAT
PO 2	Write and present a substantial technical report / document	3	CIE/SEE/AAT

PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program	2	CIE/SEE/AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	3	CIE/SEE/AAT

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	✓	✓	✓	✓	-	-
CO2	✓	✓	-	✓	-	-
CO3	✓	✓	-	✓	-	-
CO4	✓	✓	✓	✓	-	-
CO5	✓	✓	✓	-	-	-
CO6	✓	✓	✓	-	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO1	**PO 1**	Investigating various sensors and their applications in IoT involves research and **problem-solving**, requiring an in-depth understanding of how these sensors work. This will foster the ability to tackle **real-world IoT challenges** by applying **scientific principles and methodologies.**	**6**
	PO 2	After researching the sensor technologies and their applications, **documenting** and presenting findings requires the development of **technical writing and presentation skills**. This ensures clear communication of complex technical information to stakeholders, both in **written and oral** forms.	**4**
	PO 3	Mastery in understanding the different types of sensors used in IoT, along with their working principles and use cases, demonstrates a **higher level of expertise** in the field. The ability to apply this knowledge effectively shows a deep understanding beyond the basics, ensuring **comprehensive expertise** in the specialization.	**4**

	PO 4	Exploring sensor technologies in IoT applications equips learners to understand user needs and apply **scientific principles** to formulate and abstract real-world problems. It encourages **innovative thinking** for solution design, **experiment planning**, and effective use of resources like simulation tools, enabling deeper insight into embedded and robotic systems.	**5**
CO2	**PO 1**	Analyzing advanced sensors involves deep investigation into their evolving features and technological improvements. This develops the learner's ability to independently **research modern sensor capabilities** and apply them to solve accuracy and reliability issues in **real-world** industrial settings.	**6**
	PO 2	After researching the sensor technologies and their applications, **documenting and presenting** findings requires the development of technical **writing and presentation skills.** This ensures clear communication of complex technical information to stakeholders, both in **written and oral forms.**	**4**
	PO 4	Applies scientific principles to understand and integrate sensor technologies into embedded systems. Emphasizes **problem formulation and creative thinking** to develop **innovative**, sensor-based solutions. Involves managing the **design process and validating** system performance for effective use in IoT, healthcare, and communication domains.	**5**
CO3	**PO 1**	Understanding the architecture of wireless sensor systems involves identifying practical sensing **challenges and investigating** system modules to design effective solutions. Encourages independence, **self-driven** exploration, and the ability to implement and demonstrate functional wireless sensing setups with attention to quality and feasibility.	**5**
	PO 2	Demonstrating wireless sensor architecture involves not only technical understanding but also effective communication of the system's design, function, and integration. This requires clear **written documentation, proper referencing, and structured presentation**. Presenting insights from sensor system analysis reflects subject **knowledge, clarity, and communication skill**s—key to technical reporting.	**4**

	PO 4	Applying embedded system design concepts through problem **identification, experimentation, and solution development** using modern tools and methodologies. Encourages **innovation and scientific reasoning** to develop practical implementations for **real-world domains** such as IoT and communication. Reinforces the design, analysis, and validation of systems aligned with user needs and technological advancements.	**6**
CO4	**PO 1**	Understanding the operation of energy storage modules requires independence in conducting focused research. The ability to **identify problems** related to energy inefficiency and **implement solution**s in real-time scenarios reflects a **self-driven approach**. Demonstrating technical understanding in selecting and integrating modules also reflects the **quality of work** in addressing power reliability in wireless systems.	**6**
	PO 2	Exploring energy storage for wireless sensors involves effective **written communication and clarity in presentation** of technical concepts and configurations. Preparing structured documentation with **appropriate grammar and references** highlights the learner's subject knowledge and their ability to identify problems or opportunities in energy management for sensor networks.	**4**
	PO 3	Recognizing how energy storage systems enhance sensor reliability demonstrates knowledge and understanding of embedded applications. This includes **problem abstraction, use of creativity, and innovative design**. Mastery is shown through the design process, use of **modern tools, solution development, and validation** of the system's energy performance.	**5**
	PO 4	Energy storage integration into embedded systems showcases scientific principles, **problem-solving, and solution implementatio**n. Understanding user needs and applying **software tools or literature search methods** for optimal design reflects creativity and a deep grasp of IoT-based embedded applications. This competency supports **experimentation, evaluation, and project developmen**t in energy-aware system design.	**5**

CO5	**PO 1**	Understanding the NEST sensor ecosystem encourages independent investigation into energy-efficient technologies. It involves **problem identification and implementation** of intelligent home automation systems. The analysis and integration of such ecosystems reflect a **self-driven mindset and quality of work** in addressing real-world energy and automation challenges.	**6**
	PO 2	IDescribing the NEST ecosystem's working requires **clear written communication, structured presentation**, and proper referencing of smart home technologies. Presenting its functionality and benefits showcases clarity, strong subject knowledge, and an ability to identify opportunities in energy-efficient design.	**3**
	PO 3	Explaining the NEST sensor system showcases knowledge and understanding of intelligent embedded systems in real-time applications. It involves **problem abstraction, innovative product design, and the use of modern tools for solution development, evaluation**, and result validation—all demonstrating a higher level of mastery in the domain of smart technologie	**5**
CO6	**PO 1**	Understanding how hardware components interact requires identifying implementation-level challenges and exploring how to resolve them using platform-specific strategies. This develops **problem identification, quality of work, and self-driven investigation** needed in embedded system tasks.	**5**
	PO 2	Explaining communication protocols, circuit integration, and hardware programming principles strengthens the ability to **document processes, clarify design logic, and effectively present technical solutions** in embedded applications.	**4**
	PO 3	Mastery of embedded hardware interaction indicates deep knowledge, **innovative thinking, and the ability to design and implement hardware-software systems** that go beyond basic undergraduate expectations.	**5**

Note: For Key Attributes refer **Annexure - I**

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

.

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	6	4	4	5	-	-
CO 2	6	4	-	5	-	-
CO 3	5	4	-	6	-	-
CO 4	6	4	5	5	-	-
CO 5	6	3	5	-	-	-
CO 6	5	4	5	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	100	66.6	44.4	50	-	-
CO 2	100	66.6	-	50	-	-
CO 3	83.3	66.6	-	60	-	-
CO 4	100	66.6	55.5	60	-	-
CO 5	100	50	55.5	-	-	-
CO 6	83.33	66.66	55.5	-	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.
0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	2	2	-	-
CO 2	3	3	-	2	-	-
CO 3	3	3	-	3	-	-
CO 4	3	3	2	3	-	-
CO 5	3	2	2	-	-	-
CO 6	3	3	2	-	-	-
TOTAL	**18**	**17**	**8**	**10**	**-**	**-**
AVERAGE	**3**	**2.8**	**2**	**2.5**	**-**	**-**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	-	Tech - Talk	✓	Certification	-
Term Paper	-	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVII SYLLABUS:

MODULE I	**INTRODUCTION TO INTERNET OF THINGS**
	Internet of things promises, definition. scope, sensorsfor IoT applications, structure of IoT, IoT map device.
MODULE II	**IOT SENSORS**
	Industrial sensors, description and characteristics, first generation, description and characteristics, advanced generation, description and characteristics, integrated IoT sensors, description and characteristics, polytonic systems, description and characteristics, sensors' swarm, description and characteristics, printed electronics, description and characteristics IoT generation-roadmap.
MODULE III	**IOT ANALYSIS**
	Wireless Sensor Structure, processor, radio interface, ADC, Energy Storage Module, energy usage and storage, Power Management Module, power requirements. Optimizing power consumption, lower power modes, monitoring power usage, testing and verifying performance, RF Module, basic components, modulation techniques, communication protocols UART and other serial interfaces, PWM, RTC, WDT.
MODULE IV	**IOT DEVELOPMENT EXAMPLES**
	ACOEM Eagle – EnOcean Push Button – NEST Sensor – Ninja Blocks -Focus on Wearable Electronics, Tesla IOT car, Hitachi, PTC Thing Worx, Caterpillar, Tom farms.
MODULE V	**IOT APPLICATIONS**

	Creating the sensor project, preparing raspberry Pi/ ARM cortex, clyster libraries, hardware, interacting with the hardware, interfacing the hardware, internal representation of sensor values, persisting data, external representation of sensor values, exporting sensor data, creating the actuator project, hardware, interfacing the hardware, creating a controller, representing sensor values, parsing sensor data, calculating control states, creating a camera, hardware accessing the serial port on raspberry Pi/ ARM Cortex, interfacing the hardware, creating persistent default settings, adding configurable properties, persisting the settings, working with the current settings, initializing the camera.

TEXTBOOKS

1. Dr. Guillaume Girardin, Antoine Bondable, Dr. Eric Mounier, Technologies Sensors for the Internet of Things Businesses and Market Trends 2014 -2024, Yole Development Copyrights, 2014.
2. Peter Washer, 'Learning Internet of Things', Packet Publishing, 2015.

REFERENCE BOOKS:

1. Editors Ovidiu Vermes a Peter Friess, 'Internet of Things – From Research and Innovation to Market, 2014.
2. N. Ida, Sensors, Actuators and Their Interfaces, SciTech Publishers, 2014.

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/electronics-and-communication-engineering-autonomous/Internet Of Things and Applications

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	https://lms.iare.ac.in/index?route=course/details&course_id=354
CONTENT DELIVERY (THEORY)			
2	Introduction to IoT: Definition, Scope, Promises,Scope of IoT Applications	CO1	T1:1.2
3	Sensors for IoT Applications	CO1	T1:1.3
4	Structure of IoT	CO1	T1:1.4
5	IoT Map Device Overview	CO1	T1:1.5
6	Industrial Sensors – Description and Characteristics	CO2	T1:2.1

7	First Generation Sensors – Description and Characteristics	CO2	T1:2.2
8	Advanced Generation Sensors – Description and Characteristics	CO2	T1:2.3
9	Integrated IoT Sensors – Description and Characteristics	CO2	T1:2.4
10	Polytonic Systems – Description and Characteristics	CO2	T1:2.5
11	Sensor Swarm – Description and Characteristics	CO2	T1:2.6
12	Printed Electronics – Description and Characteristics	CO2	T1:2.7
13	IoT Generation Roadmap	CO2	T1:2.8
14	Hardware for Sensors	CO2	T1:3.1
15	Interfacing the Hardware	CO2	T1:3.2
16	Internal Representation of Sensor Values	CO2	T1:3.3
17	Persisting Data from Sensors	CO2	T1:3.4
18	External Representation of Sensor Values	CO2	T1:3.5
19	Exporting Sensor Data	CO2	T1:3.6
20	Creating Actuator Project – Overview	CO2	T1:3.7
21	Actuator Project Hardware	CO2	T1:3.8
22	Interfacing Actuator Hardware	CO2	T1:3.9
23	Creating a Controller for Sensor Data	CO2	T1:3.10
24	Representing Sensor Values in a Controller	CO2	T1:3.11
25	Parsing Sensor Data	CO2	T1:3.12
26	Calculating Control States	CO2	T1:3.13
27	Creating a Camera – Hardware	CO3	T1:4.1
28	Accessing Serial Port on Raspberry Pi / ARM Cortex	CO3	T1:4.2
29	Interfacing Camera Hardware	CO3	T1:4.3
30	Persistent Default Settings for IoT Devices	CO3	T1:4.4
31	Configurable Properties of IoT Devices	CO3	T1:4.5
32	Working with Current Settings in IoT Devices	CO3	T1:4.6
33	Initializing IoT Camera	CO3	T1:4.7
34	Wireless Sensor Node Structure: Processor, Radio Interface, ADC	CO3	T1:5.1
35	Energy Storage and Usage in IoT	CO3	T1:5.2
36	Power Management Modules in IoT	CO3	T1:5.3
37	Power Requirements in IoT Nodes	CO3	T1:5.4
38	Optimizing Power Consumption	CO3	T1:5.5
39	Low Power Modes for IoT Devices	CO6	T1:5.6
40	Monitoring Power Usage in IoT	CO4	T1:5.7
41	Testing and Verifying IoT Performance	CO5	T1:5.8
42	RF Module – Basic Components	CO6	T1:5.9

43	RF Modulation Techniques	CO6	T1:5.10
44	RF Communication Protocols	CO4	T1:5.11
45	EnOcean Push Button – Overview	CO5	T1:5.12
46	PTC ThingWorx and Caterpillar IoT Applications	CO5	T1:5.13-5.15
PROBLEM SOLVING/ CASE STUDIES			
47	Problem Solving: Identify suitable sensors for a smart irrigation system	CO1	Practical
48	Problem Solving: Design IoT-based temperature monitoring using Raspberry Pi	CO2	Practical
49	Problem Solving: Develop a simple actuator control logic for a smart home fan	CO2	Practical
50	Problem Solving: Create a power optimization algorithm for IoT device battery usage	CO3	Practical
51	Problem Solving: Design a wireless node communication using RF module	CO4	Practical
52	Problem Solving: Analyze ThingWorx IoT application for performance improvement	CO5	Practical
53	Problem Solving: Implement sensor data export and parsing in IoT system	CO3	Practical
54	Problem Solving: Develop SPI communication between Raspberry Pi and peripheral device	CO4	Practical
55	Problem Solving: Design a CAN-based communication for agricultural IoT sensors	CO6	Practical
DISCUSSION ON DEFINITION AND TERMINOLOGY			
56	: Introduction to Internet of Things	CO 1	T1: 1.1-1.5
57	IOT Sensors	CO 2	T1: 7.1-7.2
58	IOT Analysis	CO 3	R2:8.4-10
59	IOT Developement Examples	CO 4	T2: 2.1-2.4
60	IOT Applications	CO 5	T2: 2.5-2.6
DISCUSSION ON QUESTION BANK			
61	Introduction to Internet of Things	CO 1	T1: 1.1-1.5
62	IOT Sensors	CO 2	T1: 7.1-7.2
63	IOT Analysis	CO 3	R2:8.4-10
64	IOT Developement Examples	CO 4	T2: 2.1-2.4
65	IOT Applications	CO 5	T2: 2.5-2.6

Course Coordinator **HOD,ECE**

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering(ES)**				
Course Title	**ARM Cortex Architecture and Programming**				
Course Code	BESD14				
Program	M.Tech				
Semester	II				
Course Type	Core				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. B Ravi Kumar, Associate Professor				

I COURSE OVERVIEW:

This course focuses on the fundamental concepts and practical aspects of ARM Cortex-M-based microprocessor, incorporates architecture, programming and interfacing aspects. ARM Cortex-M processor based microcontroller, TM4C123, Cortex-M programming, the basics of Cortex-M assembly programming, interfacing different real- life hardware devices to the ARM Cortex-M controller. For this part we have selected the Texas Instruments TM4C123-based microcontroller hardware platform. the workings of general purpose input-output (GPIO) pins, their features, possible alternate functionalities, and interfacing of Output (LED, LCD displays) as well as input (switches and keypads) devices. The first interfacing example that toggles an on-board green LED is developed using both assembly and C programming languages to elaborate the relation between C and assembly programming

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB23	VI	Embedded System Design
M.Tech	BESD02	I	Microcontrollers and Programmable Digital Signal Processing

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
ARM Cortex Architecture and Programming	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos

x	Others

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted. CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Assignment / Quiz and 10 marks for Alternative Assessment Tool (AAT). Two CIE examinations are Compulsory and sum of the two exams, along with the scores obtained in the assignment / Quiz and AAT shall be considered for computing the final CIA of a student in a given course. Advance notification for the conduction of Assignment / Quiz / AAT is mandatory and the uploading and conduction is lies with the office of planning, monitoring and continuing studies.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIE-1	CIE-2	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Assignment / Quiz	5 Marks	5 Marks		10 Marks
Alternative Assessment Tool (AAT)	5 marks	5 marks		10 marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:

The assignments develop different skills and increase their knowledge base significantly. It provides the evidence for the faculty that the students have achieved the goals. It helps the faculty to evaluate the student's understanding of the course. Assignment will be evaluated for 5 marks. The assignment has to either handwritten / typed and uploaded to the Samvidha portal

at the end of either CIE1 or CIE2, based on the questions provided by the course coordinator for that semester.

Quiz:
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2.

Alternative Assessment Tool (AAT):
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. The AAT may include tech talk, case studies, seminars, term paper, open ended experiments, partial reproduction of research work, oral presentation of research work, developing a generic tool-box for problem solving, report based on participation in create-a-thon, makea-thon, code-a-thon, hack-a-thon conducted by reputed organizations / any other. etc.

VI COURSE OBJECTIVES:

The students will try to learn:

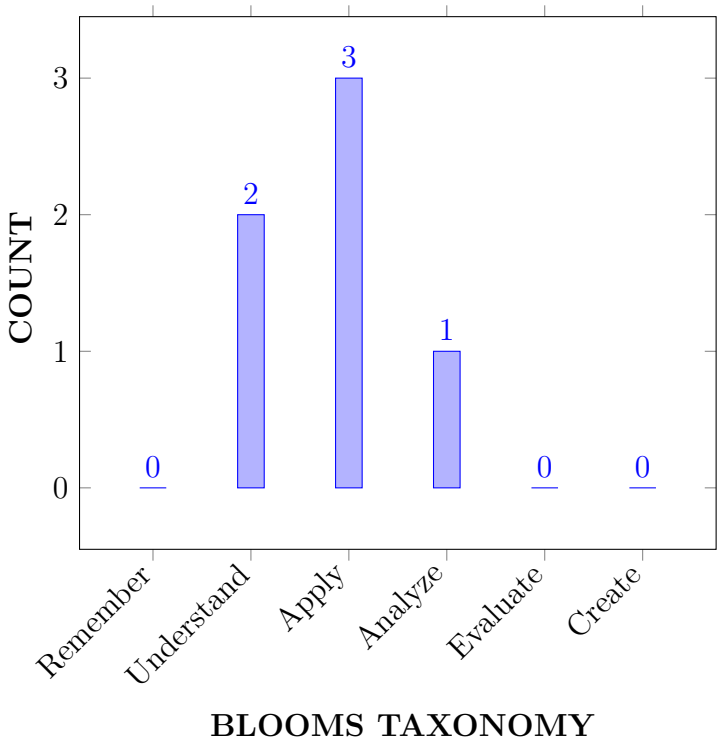
I	Architectural features of ARM cortex-M Processor
II	Programming of ARM using assembly language
III	TM4C123 Microcontroller architecture and interfacing.
IV	Configuration of TM4C123 microcontroller communication interfaces.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Describe** the features of ARM Cortex-M processors for signal description and architecture.	Understand
CO 2	**Illustrate** the programmer 's model of ARM processor and test	Apply
CO 3	**Executing** programming model using high level and low-level languages	Apply
CO 4	**Demonstrate** the internal architecture and TM4C123 Microcontroller various modes of operation of the devices used for interfacing memory and I/O devices with ARM processor	Understand
CO 5	**Apply** the memory management architecture for allocating the MMU	Apply
CO 6	**Analyze** floating point processor architecture and its architectural its architectural	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	3	CIE/SEE/AAT

PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program	2	CIE/SEE/AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	2	CIE/SEE/AAT

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	✓	-	✓	✓	-	-
CO2	✓	-	-	-	-	-
CO3	✓	-	✓	✓	-	-
CO4	✓	-	-	✓	-	-
CO5	✓	-	-	✓	-	-
CO6	✓	-	✓	✓	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO1	**PO 1**	**Understand** the concepts of ARM Cortex-M3 processor by applying **Scientific principles and methodology, Use creativity** to establish architecture , identify **Problem formulation** for interfacing **problems**, **Implement** different applications by using arm processor.	**6**
	PO 3	Analyze the given **problem statement** and **formulate** the kernel, and other components in embedded systems and **use creativity** to establish **innovative solutions** for embedded system , **Interpret** the result on various applications	**4**
	PO 4	**Develop** ARM Cortex-M3 processor for various **Problems** in pre processors , **implement** advanced arm processor for real time applications	**4**
CO2	**PO 4**	Illustrate the concept(knowledge) of ARM cortex –M assembly language, Addressing modes, Instruction set: Data processing instructions, Memory access instructions, Branch and control instructions to the solution of complex engineering problem	**6**

CO3	**PO 1**	Illustrate components of real time operating systems (knowledge) to integrate the software and hardware components (mathematical model) the design of reliable embedded system by applying the principles of mathematical model and science	**5**
	PO 3	Construct the high level of integration in embedded applications using TM4C123 Microcontroller	**4**
	PO 4	Independently carry out research / investigation and development work to solve practical problems.	**4**
CO4	**PO 1**	Analyze (problem statement) finite state machine by applying solutions for complex engineering problems and design system components.	**6**
CO5	**PO 1**	Create (Engineering knowledge) semaphore token for the execution of one or more threads in mutual exclusion by applying the principles of mathematics, science.	**5**
	PO 4	Identify the given problem statement and solve it using synchronization or mutual exclusion by applying mathematical properties.	**3**
CO6	**PO 1**	Understand (knowledge) the SPI Modes of Operation, SPI Signal Timing ,SPI Details on TM4C123 Microcontroller , CAN Details on TM4C123 Microcontroller	**6**
	PO 3	Analyze the given **problem statement** and **formulate** the kernel, and other components in TM4C123 Microcontroller and **use creativity** to establish **innovative solutions** for embedded system , **Interpret** the result on various applications	**4**
	PO 4	Understand (knowledge) SPI model and TM4C123 Microcontrollers by applying its peripheral interface.	**3**

Note: For Key Attributes refer **Annexure - I**

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	6	-	4	4	-	-
CO 2	-	-	-	6	-	-
CO 3	5	-	4	4	-	-
CO 4	6	-	-	-	-	-
CO 5	5	-	-	3	-	-
CO 6	6	-	4	3	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	100	-	44	40	-	-
CO 2	-	-	-	60	-	-
CO 3	83	-	44	40	-	-
CO 4	100	-	-	-	-	-
CO 5	83	-	-	30	-	-
CO 6	100	-	44	30	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.
0 - 0 ≤ C≤ 5% – No correlation
1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	-	2	2	-	-
CO 2	-	-	-	3	-	-
CO 3	3	-	2	2	-	-
CO 4	3	-	-	-	-	-
CO 5	3	-	-	1	-	-
CO 6	5	-	2	1	-	-
TOTAL	**15**	**-**	**6**	**9**	**-**	**-**
AVERAGE	**3**	**-**	**2**	**1.8**	**-**	**-**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	-	Tech - Talk	✓	Certification	-
Term Paper	✓	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
-	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVII SYLLABUS:

MODULE I	**ARM CORTEX-M ARCHITECTURE**
	ARM instruction, Set architecture, Register set, Operating modes, Processor reset sequence, Pipelined architecture and data path, Memory address map, Bus system and bus matrix, Memory and peripherals, Bit banding, System stack architecture, Debug system, Exceptions and interrupts
MODULE II	**ASSEMBLY LANGUAGE PROGRAMMING**
	Software development process, ARM cortex –M assembly language, Addressing modes, Instruction set: Data processing instructions, Memory access instructions, Branch and control instructions
MODULE III	**TM4C123 MICROCONTROLLER**
	TM4C123 Microcontroller Block Diagram, The hardware development board for TM4C123, Microcontroller peripherals, Configuring microcontroller pins as GPIOs, Input – output interfacing for LED and Switch, Methods for input-output synchronization. UART and other serial interfaces, PWM, RTC, WDT.
MODULE IV	**INTERFACING WITH TM4C123**
	Configuration of interrupts and exceptions, UART configuration, I2C configuration, SPI configuration, CAN configuration, ADC configuration
MODULE V	**SERIAL PERIPHERAL INTERFACE**
	SPI Modes of Operation, SPI Signal Timing ,SPI Details on TM4C123 Microcontroller , CAN Details on TM4C123 Microcontroller , GPIO Configuration for CAN Alternate Function

TEXTBOOKS

1. Muhammad Tahir and Kashif Javed, ARM Microprocessor Systems – Cortex-M Architecture, programming and Interfacing, Florida: CRC Press, 2017.
2. https://toaz.info/doc-view-2: : ARM® Microprocessor Systems by M. Tahir and Kashif Javed Platform PDF Viewer to download ARM® Microprocessor Systems by M. Tahir and Kashif Javed

REFERENCE BOOKS:

1. Jonathan W Valvano, Embedded Systems: Real time interfacing to ARM Cortex-M Microcontrollers, 5th ed. Self Published, 2017
2. Joseph Yiu, The Definitive Guide to the ARM Cortex-M3, 2nd ed. USA: Newnes Publishers , 2010.
3. Andrew N Sloss, Dominic Symes, Chris Wright, ARM System Developer's Guide -Designing and Optimizing System Software, San Francisco: Morgan Kaufmann Publishers, 2014.

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/electronics-and-communication-engineering-autonomous/Microcontrollers and Programmable Digital Signal Processing

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	https://lms.iare.ac.in/index?route=course/details&course_id=354
CONTENT DELIVERY (THEORY)			
2	Understanding the ARM ARM instruction, Set architecture	CO 1	T1: 1.1-1.5
3	Register set, Operating modes	CO 1	T1: 3.2-3.5
4	Processor reset sequence	CO 1	T1: 3.5-3.7
5	Pipelined architecture and data path	CO 1	T1: 4.1-4.2
6	Memory address map	CO 1	T1: 4.2-4.3
7	Bus system and bus matrix	CO 1	T1: 4.3-4.4
8	Memory and peripherals, Bit banding	CO 1	T1:5.1-5.2
9	System stack architecture, Debug system, Exceptions and interrupts	CO 1	T1:5.2,5.5
10	Software development process	CO 1	T1: 6.1-6.2
11	ARM cortex –M assembly language	CO 1	T1: 6.1-6.2
12	Addressing modes, Instruction set	CO 2	T1: 7.1-7.2
13	Data processing instructions	CO 2	T1: 7.1-7.2
14	Memory access instructions,	CO 2	T1: 7.4-7.5
15	Branch and control instructions	CO 2	T1: 7.4-7.5
16	TM4C123 Microcontroller Block Diagram	CO 2	T2: 7.6-8.1
17	The hardware development board for TM4C123	CO 2	T2: 7.6-8.1
18	Microcontroller peripherals	CO 2	T1: 8.2-8.5
19	Configuring microcontroller pins as GPIOs	CO 2	T1:9.1-9.2
20	Tail Input – output interfacing for LED and Switch	CO 2	T1: 9.1-9.2
21	Input – output interfacing for LED and Switch	CO 3	R2:8.4,8.10
22	Methods for input-output synchronization	CO 3	R2:8.4- 10
23	Configuration of interrupts and exceptions	CO 3	R2:8.4
24	Configuration of interrupts and exceptions	CO 3	R2: 8.14-8.16
25	Configuration of interrupts and exceptions	CO 3	R2: 8.14-8.16

26	UART configuration	CO 3	R2: 8.16,8.17
27	UART configuration	CO 3	R2:8.22
28	I2C configuration	CO 3	R2:8. 27
29	I2C configuration	CO 3	R2:8. 28
30	SPI configuration,	CO 4	T2: 2.1-2.2
31	CAN configuration, ADC configuration	CO 4	T2:2.2-2.4
32	Multi port memory organization	CO 4	T2: 2.1-2.4
33	Study the features of architectural structure of P-DSP- MAC unit	CO 4	T2:3.1-2.1
34	Barrel shifters with examples	CO 4	T2: 2.5
35	Understand the Introduction to TI DSP processor family.	CO 4	T2: 2.5
36	Study the VLIW architecture	CO 4	T2: 2.5,13.4
37	TMS320C6000 series architecture study,	CO 4	T2: 2.5,13.4
38	TMS320C6000 family architecture study,	CO 5	T2: 2.5-2.6
39	Understand data paths	CO 5	T2: 13.3
40	SPI Modes of Operation	CO 5	T2:13.6-13.5
41	SPI Signal Timing .	CO 5	T2: 13.3-13.4
42	SPI Details on TM4C123 Microcontroller	CO 6	T2: 13.5
43	CAN Details on TM4C123 Microcontroller	CO 6	T2:13.6
44	CAN Details on TM4C123 Microcontroller	CO 6	T2:13.11-12
45	GPIO Configuration for CAN Alternate Function	CO 6	T2:13.11-12
46	GPIO Configuration for CAN Alternate Function	CO 6	T2:13.12-14
PROBLEM SOLVING/ CASE STUDIES			
47	Problems on registers, operation modes	CO 1	T1: 1.1-1.5
48	Problems on memory maps, memory access attributes	CO 1	T1: 3.2-3.5
49	Problems on priority, vector tables	CO 2	T1: 7.1-7.2
50	Problems on interrupt sequences, interrupt latency.	CO 2	T1: 7.1-7.2
51	Problems on TM4C123 microcontroller- internal memory	CO 3	R2:8.4,8.10
52	interfacing for LED	CO 3	R2:8.4 - 10
53	Problems on barrel shifters	CO 4	T2: 2.1-2.4
54	UART configuration	CO 5	T2: 2.5-2.6
55	SPI configuration, CAN configuration, ADC configuration	CO 6	T2:13.11-12
DISCUSSION ON DEFINITION AND TERMINOLOGY			
56	Systems ARM cortex-m3 processor	CO 1	T1: 1.1-1.5
57	Exceptions and interrupts	CO 2	T1: 7.1-7.2
58	TM4C123 microcontroller	CO 3	R2:8.4-10
59	SPI Signal Timing	CO 4	T2: 2.1-2.4

60	GPIO Configuration for CAN Alternate Function	CO 5	T2: 2.5-2.6
DISCUSSION ON QUESTION BANK			
61	Systems ARM cortex-m3 processor	CO 1	T1: 1.1-1.5
62	Exceptions and interrupts	CO 2	T1: 7.1-7.2
63	TM4C123 microcontroller	CO 3	R2:8.4-10
64	CAN configuration	CO 4	T2: 2.1-2.4
65	SPI Signal Timing	CO 5	T2: 2.5-2.6

Course Coordinator **HOD,ECE**

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING (ES)**				
Course Title	**EMBEDDED SYSTEMS FOR MACHINE LEARNING**				
Course Code	BESD15				
Program	M.Tech				
Semester	II				
Course Type	Professional Elective -III				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. B. Surekha Reddy, Assistant Professor				

I COURSE OVERVIEW:

This course aims to provide students with a solid foundation in embedded systems for machine learning. Students will learn about the design, development as well as the key components involved in creating efficient and reliable embedded solutions. This course aims to provide students with the skills needed to design and implement machine learning applications on embedded systems, taking into consideration the unique challenges posed by resource-constrained environments.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
M.Tech	BESD01	II	Embedded System Programming

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Embedded Systems for Machine Learning	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	**x**	MOOC
x	Open Ended Experiments	✓	Seminars	**x**	Mini Project	**x**	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 40 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question. The emphasis on the questions is broadly based on the following criteria:

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course. The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty

Table 3: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The student has to answer any 4 questions out of five questions, each carrying 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Assignment:

To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Quiz:
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

Alternative Assessment Tool (AAT):
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center. The AAT may include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

I	The difference between embedded systems and general-purpose systems.
II	Develop an understanding of hardware/software co-design and itssignificance.
III	Implement basic networking and communication capabilities in embedded systems.
IV	Define and explain the fundamental concepts of machine learning.
V	Provide an overview of the historical context and evolution of machine learning.

VII COURSE OUTCOMES:

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

CO 1	**Describe** the characteristics, challenges, and constraints of embedded systems for Machine Learning.	Remember
CO 2	**Apply** the suitable memory technology and other components for different applications to meet the evergrowing needs of the embedded applications.	Apply
CO 3	**Choose** the fundamental components that make up an embedded board to implement an Instruction Set Architecture 's features in a processor.	Evaluate
CO 4	**Apply** machine learning techniques to appropriate problems.	Apply
CO 5	**Apply** Evaluation, hypothesis tests and compare learning techniques for various problems.	Evaluate
CO 6	**Analyze** real time problems in different areas to solve using Reinforcement learning technique.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	2	SEE/CIE/AAT
PO 2	Write and present a substantial technical report / document.	2	SEE/CIE/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	1	SEE/CIE/AAT
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	3	SEE/CIE/AAT
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	3	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	✓	✓	✓
CO 2	✓	✓	-	✓	✓	✓
CO 3	✓	✓	-	✓	✓	✓
CO 4	✓	✓	-	✓	✓	✓
CO 5	✓	✓	-	✓	✓	✓
CO 6	✓	✓	-	✓	✓	✓

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Understanding the constraints and architecture of embedded systems for ML forms the foundation of specialized knowledge, enabling students to master the integration of ML into embedded environments.	2
	PO 2	Students should be able to write reports that describe the challenges and constraints of embedded systems for ML.	3
	PO 4	Grasping system limitations and operational characteristics prepares students to design embedded solutions suited for real-world applications in areas such as IoT, medical electronics, and smart devices.	4
	PO 5	Students could contribute indirectly if group projects or discussions are involved in researching and addressing embedded system challenges.	1
	PO 6	Exploring system constraints and their impact on machine learning applications in embedded systems requires continuous learning of emerging technologies, making students aware of the importance of lifelong learning.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Selecting the appropriate memory technologies involves researching various options and understanding their impact on embedded system performance for different applications.	2
	PO 2	Documenting the selection of memory technologies and their application in embedded systems will require students to present their findings clearly, likely in a technical report.	4
	PO 4	The selection and application of memory technologies and components are critical to the design of embedded systems that serve various real-world applications, such as IoT, medical electronics, and signal processing.	5
	PO 5	Collaborating with a team to select and integrate appropriate memory technologies requires working in a multidisciplinary environment to meet system requirements.	3
	PO 6	As embedded systems evolve, continuous learning about new memory technologies is essential to remain up-to-date with industry trends and emerging needs in embedded system design.	4
CO 3	PO 1	An investigative approach to selecting the right components for an embedded system, which involves researching hardware compatibility and processor architecture.	2
	PO 2	Creating technical documentation that outlines the selected components and how they implement ISA features. It emphasizes the ability to communicate complex technical concepts clearly.	4
	PO 4	Choosing the right components for an embedded system is fundamental to designing customized embedded solutions that serve real-world applications and integrate them with ISA features.	5
	PO 5	Collaborative work is necessary when selecting and assembling the components for an embedded board, as this requires input from multiple team members with different expertise in hardware and software.	4
	PO 6	The process of selecting components and understanding ISA features is continuously evolving with advancements in embedded system designs, emphasizing the need for lifelong learning.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 1	Applying ML techniques to real-world problems, requiring a research-driven approach to identify which techniques are best suited for specific applications.	2
	PO 2	Students may need to document their ML application process, providing written reports that detail the technique applied, the problem it solved, and the results obtained.	3
	PO 4	The application of ML techniques is critical to designing embedded solutions that tackle real-world problems in fields such as IoT or medical electronics, demonstrating applied engineering knowledge.	5
	PO 5	ML application often involves collaboration with interdisciplinary teams, especially when designing embedded systems that integrate ML for practical applications.	3
	PO 6	The rapidly evolving field of machine learning requires students to stay current with emerging techniques and technologies, fostering a mindset of lifelong learning.	4
CO 5	PO 1	Evaluating and hypothesis testing of different learning techniques, requiring a research-based approach to assess the best technique for solving a given problem.	2
	PO 2	To properly evaluate and compare learning techniques, students may need to document their findings and present comparisons of various techniques, including the results of their hypothesis testing.	4
	PO 4	The ability to compare and evaluate learning techniques is essential to designing embedded systems that meet specific application needs, especially when deploying ML models in real-world environments.	5
	PO 5	Collaborating within a team is crucial when evaluating models and hypothesis testing as multiple perspectives may be needed to assess the best approach for different problems.	3
	PO 6	The evaluation of various techniques and models requires students to stay updated on the latest ML techniques, highlighting the importance of lifelong learning in an ever-evolving field.	4
CO 6	PO 1	Problem-solving through the application of Reinforcement Learning (RL), a cutting-edge technique, which involves research and investigation to identify the best solutions for real-time issues.	2
	PO 2	Documenting the analysis of real-time problems and the application of RL techniques to solve them is essential for clear communication of the solution, which may be required in reports.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	The application of RL to solve real-time problems demonstrates a deep understanding of embedded systems and real-world applications, a critical skill for professional embedded systems design.	5
	PO 5	Collaboration is often essential when analyzing real-time problems and applying RL techniques, as multidisciplinary knowledge may be required to address various aspects of the problem.	4
	PO 6	Solving real-time problems using RL involves staying current with emerging RL techniques and applying them effectively, reinforcing the need for lifelong learning in advanced machine learning and embedded systems.	5

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	4	2	-	4	2	2
CO 2	4	3	-	5	4	4
CO 3	4	3	-	5	6	3
CO 4	4	2	-	5	4	4
CO 5	4	3	-	5	4	4
CO 6	4	2	-	5	6	5

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 10	PO 12
	6	6	9	10	7	8
CO 1	66.66	33.33	-	40	28.57	25
CO 2	66.66	50	-	50	57.14	50
CO 3	66.66	50	-	50	85.71	37.5
CO 4	66.66	33.33	-	50	57.14	50
CO 5	66.66	50	-	50	57.14	50
CO 6	66.66	33.33	-	50	85.71	62.5

XIV COURSE ARTICULATION MATRIX (PO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	-	2	1	1
CO 2	2	2	-	2	2	2
CO 3	2	2	-	2	3	1
CO 4	2	1	-	2	2	2
CO 5	2	2	-	2	2	2
CO 6	2	1	-	2	3	2
TOTAL	**12**	**9**	**-**	**12**	**14**	**10**
AVERAGE	**2**	**2**	**-**	**1**	**2**	**1**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	-	Tech - Talk	✓	Certification	-
Term Paper	-	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVI SYLLABUS:

MODULE I	**INTRODUCTION TO EMBEDDED SYSTEMS**
	Overview of microcontrollers and microprocessors Architecture, memory organization, and I/O operations, Selection criteria for choosing microcontrollers, definition and characteristics of embedded systems.
MODULE II	**TYPICAL EMBEDDED SYSTEM**
	Core of the Embedded System: General purpose and domain specific processors, ASICs, PLDs, commercial off- theshelf components (COTS), memory: ROM, RAM, memory according to the type of interface, memory shadowing, memory selection for embedded systems, sensors and actuators, communication interface: onboard and external communication interfaces.
MODULE III	**INTRODUCTION TO MACHINE LEARNING**

	Introduction: Examples, Applications of Machine Learning Applications - Learning Associations, Classification, Regression, Unsupervised learning, Reinforcement learning. **Supervised Learning:** Regression: Introduction to Linear Regression and Multiple Linear Regression, KNN. Measuring regression model performance - R Square, Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE) .**Classification:** Support vector machine- Characteristics, Linear SVM, Naive Bayes Classifier, KNN classifier, Logistic Regression. Measuring Classifier Performance: Precision, Recall, and Confusion Matrix.
MODULE IV	**COMBINING MULTIPLE LEARNERS**
	Combining Multiple Learners– Model Combination schemes, voting, Bagging, Boosting. **Un Supervised Learning:** K-Means, Expectation Maximization Algorithm, supervised learning after clustering, spectral clustering, choosing number of clusters.
MODULE V	**MULTILAYER PERCEPTRONS**
	The Perceptron, training a Perceptron, Learning Boolean Functions, Multilayer Perceptron's, MLP as a Universal Approximator, Backpropagation Algorithm, Training Procedures, Dimensionality Reduction, Learning Time Reinforcement Learning: Single State Case: K-Armed Bandit, Elements of Reinforcement learning, Model based Learning, Temporal Difference learning, Generalizing from examples.

TEXTBOOKS

1. Frank Vahid, Tony Givargis, "Embedded System Design", John Wiley Publications, 3 rd edition, 2006.
2. Introduction to Machine Learning, Ethem Alpaydin, 2nd edition, 2010, Prentice Hall of India.
3. Introduction to Data Mining, Tan, Vipin Kumar, Michael Steinbach, 9th Edition, 2013, Pearson.

REFERENCE BOOKS:

1. Raj Kamal, "Embedded Systems", TMH, 2nd edition, 2008.
2. Shibu K.V, "Introduction to Embedded Systems, McGraw Hill, 3rd edition, 2012.
3. Lyla, "Embedded Systems", person education, 2nd edition, 2013.
4. Machine Learning a Probabilistic Perspective, Kevin P Murphy & Francis Bach, 1st edition, 2012, MIT Press.
5. "Deep Learning", Ian Goodfellow, Yoshua Bengio, Aaron Courville, 2016, MIT Press.

XVII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	https://lms.iare.ac.in/index?route=course/details
CONTENT DELIVERY (THEORY)			
2	Pre requisites	CO1	T1-3.1-3.2
3	Overview of microcontrollers and microprocessors Architecture	CO1	T1-3.3-3.4
4	Memory organization	CO1	T1-3.3-3.4
5	Memory organization, and I/O operations	CO1	T1-3.7
6	Selection criteria for choosing microcontrollers	CO1	T1-3.5
7	Definition and characteristics of embedded systems	CO1	T1-3.6
8	General purpose and domain specific processors	CO2	T1-5.1.1
9	ASICs	CO2	T1-.1.1,5.1.2
10	PLDs	CO2	T1-5.2
11	Commercial off- theshelf components (COTS)	CO2	T1-7.10.2-3
12	Memory: ROM	CO2	T1-3.5
13	Memory: RAM	CO2	T1-4.2
14	Memory according to the type of interface	CO2	T1-4.6
15	Memory shadowing virtualization	CO2	T1-4.7
16	Memory selection for embedded systems	CO2	T1-4.10.6
17	Sensors and actuators	CO2	T1-4.11
18	Communication interface: onboard	CO2	T1-5.1.1
19	Communication interface: external communication interfaces	CO2	T1-5.1.1
20	Examples of Machine Learning	CO4	TT1-5.11
21	Applications of Machine Learning	CO4	T1-5.3.2
22	Learning Associations	CO2	T1-5.3.3,5.4
23	Classification	CO4	T1-5.4.2
24	Regression	CO2	T1-5.5
25	Unsupervised learning	CO4	T1-7.1,7.2
26	Reinforcement learning	CO4	T1-7.7.2
27	Regression: Introduction to Linear Regression and Multiple Linear Regression, KNN	CO2	T1-7.3,7.4
28	Measuring regression model performance	CO2	T1-3.5
29	R Square, Mean Square Error (MSE)	CO2	T1-7.8

30	Root Mean Square Error (RMSE)	CO2	T1-7.8.1,8.2
31	Support vector machine- Characteristics	CO4	T1-7.10,11
32	Linear SVM	CO4	T1 7.10.3.3
33	Naive Bayes Classifier	CO3	T1-5.3
34	KNN classifier	CO4	T1-7.10.
35	Logistic Regression	CO4	R3-P184
36	Measuring Classifier Performance	CO4	R3-P184
37	Precision, Recall, and Confusion Matrix	CO3	R3-P185
38	Model Combination schemes	CO4	R3-P191
39	Voting, Bagging, Boosting	CO4	R3-P190
40	K-Means	CO4	R3-P190
41	Expectation Maximization Algorithm	CO 4	T1:5.1.1
42	Serial peripheral interface bus	CO5	T1:7.3,7.4
43	supervised learning after clustering	CO5	T1:5.1.1
44	spectral clustering	CO5	T1:4.2
45	choosing number of clusters	CO5	T1:1-7.8
46	The Perceptron, training a Perceptron	CO6	T1:7.4
47	Learning Boolean Functions	CO6	T1:7.2
48	Multilayer Perceptron's	CO6	T17-7.2
49	MLP as a Universal Approximator	CO6	T1:5.3.2
50	Backpropagation Algorithm	CO6	T1:4.2
51	Training Procedures	CO6	T1:5.3
52	Dimensionality Reduction	CO6	R3:P185
53	Learning Time Reinforcement Learning	CO6	R3-P191
54	Single State Case: K-Armed Bandit	CO6	R3-P1911
55	Elements of Reinforcement learning	CO 6	R1:184
56	Model based Learning	CO6	T1:4.2
57	Temporal Difference learning	CO6	T1:4.6
58	Generalizing from examples	CO6	T1:5.11
DISCUSSION OF QUESTION BANK			
59	: INTRODUCTION TO EMBEDDED SYSTEMS	CO1	T1:4.6
60	TYPICAL EMBEDDED SYSTEM	CO2	T1:5.11
61	INTRODUCTION TO MACHINE LEARNING	CO4	T1:7.1
62	COMBINING MULTIPLE LEARNERS	CO4	T1: 7.10
63	: MULTILAYER PERCEPTRONS	CO6	T1:4.2

Course Coordinator: **HOD, ECE**
Dr. B. Surekha Reddy, Assistant Professor

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
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PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
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PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
COURSE DESCRIPTION

Branch	**Electronics and Communication Engineering(ES)**				
Course Title	**Advanced Mobile And Wireless Networks**				
Course Code	BESD19				
Program	M.Tech				
Semester	II				
Course Type	Professional Elective - IV				
Regulation	IARE- MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Ms. C V P Supradeepthi, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.TECH	-	-	Wireless communications and Networks

II COURSE OVERVIEW:

This course introduces fundamental aspects of wireless networks, with emphasis on current and next-generation wireless networks. This course will cover cellular communication, mobile radio propagation, multiple access techniques, mobility support, channel allocation, wireless PAN/LAN/MAN standards, mobile ad-hoc networks, wireless sensor networks, and routing in wireless and mobile networks. The goal of this course is to introduce the students to state-of-the-art wireless network protocols and architectures in various communication networks

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Advanced Mobile And Wireless Networks	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	**x**	MOOC
x	Open Ended Experiments	✓	Seminars	**x**	Mini Project	**x**	Videos
x	Others						

V EVALUATION METHODOLOGY

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted. CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Assignment / Quiz and 10 marks for Alternative Assessment Tool (AAT). Two CIE examinations are Compulsory and sum of the two exams, along with the scores obtained in the assignment / Quiz and AAT shall be considered for computing the final CIA of a student in a given course. Advance notification for the conduction of Assignment / Quiz / AAT is mandatory and the uploading and conduction is lies with the office of planning, monitoring and continuing studies.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIE-1	CIE-2	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Assignment / Quiz	5 Marks	5 Marks		10 Marks
Alternative Assessment Tool (AAT)	5 marks	5 marks		10 marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:

The assignments develop different skills and increase their knowledge base significantly. It provides the evidence for the faculty that the students have achieved the goals. It helps the faculty to evaluate the student's understanding of the course. Assignment will be evaluated for 5 marks. The assignment has to either handwritten / typed and uploaded to the Samvidha portal at the end of either CIE1 or CIE2, based on the questions provided by the course coordinator for that semester.

Quiz:

It is online proctor based online examination conducted either at the end of the CIE1 or CIE2.

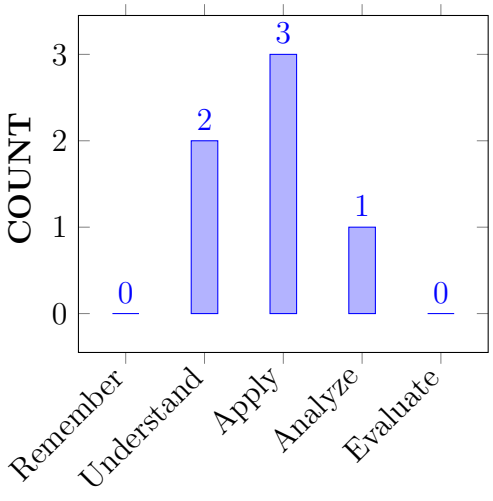
Alternative Assessment Tool (AAT):
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. The AAT may include tech talk, case studies, seminars, term paper, open ended experiments, partial reproduction of research work, oral presentation of research work, developing a generic tool-box for problem solving, report based on participation in create-a-thon, makea-thon, code-a-thon, hack-a-thon conducted by reputed organizations / any other. etc.

VI COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the fundamentals of radio propagation mechanisms for mobile communication systems.	Understand
CO 2	**Acquire** knowledge and skills in cellular systems, wireless networks, and mobile communication systems to improve coverage and capacity in cellular systems	Apply
CO 3	**Compare** different 802.11 standards in terms of data rates, frequency bands, and range to assess the performance of the WLAN	Understand
CO 4	**Analyze** WMAN technologies, such as WiMAX using channel allocation algorithms to improve network performance.	Analyze
CO 5	**Identify** common security threats in ad hoc networks using routing protocols for improving security in ad hoc networks.	Apply
CO 6	**Develop** an energy-efficient multicast routing protocol that minimizes energy consumption in multicast communication. for the sensor network	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Independently carry out research / investigation and development work to solve practical problems.
PO 2	**Problem analysis:** Write and present a substantial technical report / document.
PO 3	**Design/Development of Solutions:** Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	**Conduct Investigations of Complex Problems:**Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	**Modern Tool Usage:** Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	**The engineer and society:** Recognize the need to engage in lifelong learning through continuing education and research.

VIII HOW PROGRAM OUTCOMES ARE ASSESSED

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	2	SEE / CIE / AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	1	SEE / CIE / AAT
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	2	SEE / CIE / AAT

IX MAPPING OF EACH CO WITH PO(s)

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1		-	✓	✓		✓
CO 2		-	✓	✓		✓
CO 3			✓	✓		✓
CO 4		-	✓	✓	-	✓
CO 5		-	✓	✓		✓
CO 6		-	✓	✓		✓

X JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO1	PO 3	**Understand** the concept of wireless networks in **real time** with characteristic requirements involved in **demonstrating** of tasks in real time scenario. **Analyze and design** key characteristics of WLAN by **using of creativity** to **interface external devices**	5
	PO 4	**Understand** the concepts of embedded real time systems for real time embedded applications by **Managing** the design process and evaluate outcomes and **interpreting** of results and **validation**	4
	PO 6	**Illustrate** the concepts **knowledge** of mobile and wireless networks for real time embedded applications by using **strengthen** in embedded and advanced engineering areas by **Working** with all levels of people in team	2
CO2	PO 3	**Demonstrate** typical mobile and wireless networks by understanding embedded applications in real time scenario by**Analyzing and design innovative products Apply the complex engineering problems and their system components** by design and programming in wireless networks **for solution development**	5
	PO 4	**Make use of** time constrained wireless networks using the concepts of **engineering** fundamentals to the solution of problem formulation and abstraction to establish innovative solutions for **interpretation of results and validation**	4
	PO 6	Improve the inter task communication by **Strengthen** in embedded and advanced engineering area and time constrained wireless networks using the concepts of **engineering fundamentals** to the solution of **problem formulation** and **abstraction** to establish innovative solutions.	4
CO 3	PO 3	**Contrast** the design process and evaluation outcomes for Knowledge, understanding and demonstrations of embedded applications in real time scenario for **designing** of large scale wireless sensor networks for **Solution development** or experimentation or Implementation in **Interpretation** of results and Validation	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	**Experimental Design** for large scale wireless sensor networks by**under take research** and **development projects** in the field of wireless networks time constrained application as a member of a small group to meet design specifications.	3
	PO 6	**Build** time constrained wireless networks using the concepts of **engineering fundamentals to the solution of problem formulation and abstraction to establish innovative solutions** using WLAN rapid **design** and its programming	5
CO4	PO 3	**Problem formulation and abstraction** by **Identifying** engineering problems solution development and **implementation** in various applications of wireless communication.	4
	PO 4	**Apply** the skills and knowledge needed to serve as a professional engineer skillful at **designing** wireless networks by **Interpreting** algorithms to improve the performance of a wireless network	3
	PO 6	**Recognize** the need to engage in **lifelong learning** through continuing education and research to **improve** the performance of mobile and wireless networks.	3
CO5	PO 3	**Knowledge** understanding and demonstrations of embedded applications in real time scenario by **Examine** resource synchronization methods, **Analyze** and **design** innovative products like task scheduling in MicroC.	4
	PO 4	**Apply**the skills and knowledge needed to serve as a professional engineer skilful by learning the **architecture** of multicore wireless networks in signal processing applications by **under** take research and **development** projects in the field of wireless networks.	4
	PO 6	**Using creativity** to establish innovative solutions by **apply** the principles and architecture of multicore wireless networks to establish **solution development** or experimentation / implementation	4
CO 6	PO 3	**Demonstrate problem formulation and abstraction** in embedded WLAN for voice over IP for in **wireless networks.**	3
	PO 4	**Apply** the skills and knowledge needed to serve as a professional engineer skilful at **designing** wireless networks for effective use in inter vehicle communication networks to **enchance** the safety of moving vehicles.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 6	**Knowledge, understanding** and demonstrations of WLAN for fault tolerant applications by **applying the principles and methodology of** WiMAX by **experimental design** of application domain.	5

XI TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	-	-	5	4	-	2
CO 2	-	-	5	4	-	4
CO 3	-	-	4	3	-	5
CO 4	-	-	4	3	-	3
CO 5	-	-	4	4	-	4
CO 6	-	-	3	3	-	5

XII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	-	-	55.5	40	-	25
CO 2	-	-	55.5	40	-	50
CO 3	-	-	44	30	-	62.5
CO 4	-	-	44	30	-	37.5
CO 5	-	-	44	30	-	50
CO 6	-	-	33	30	-	62.5

XIII COURSE ARTICULATION MATRIX (PO MAPPING)

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	2	2	-	1
CO 2	-	-	2	2	-	2
CO 3	-	-	2	1	-	3
CO 4	-	-	2	1	-	1
CO 5	-	-	2	1	-	2
CO 6	-	-	1	1	-	3
TOTAL	-	-	**11**	**8**	-	**12**
AVERAGE	-	-	**1.8**	**1.3**	-	**2**

XIV ASSESSMENT METHODOLOGY DIRECT

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	-	Tech - Talk	-	Certification	-
Term Paper	✓	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XV SYLLABUS:

UNIT I	**FUNDAMENTALS OF WIRELESS COMMUNICATION TECHNOLOGY**
	Overview and applications, types of wireless and mobile networks; evolution and challenges of wireless networks; the electromagnetic spectrum; spread spectrum; frequency reuse; radio propagation mechanisms, signals, antennas; characteristics of wireless channels; modulation techniques and multiple access techniques for wireless systems.
UNIT II	**WIRELESS LANS AND PANS**
	Wireless LANs PANs: Use and design goals for WLANs; IEEE802.11 standard: architecture, infrastructure vs. Adhoc modes, physical MAC layer, CSMA/CA mechanism; HIPERLAN 1/2 standards; technical features of HOMERF; BLUETOOTH specifications and architecture; introduction to other PAN technologies and their applications.
UNIT III	**WIRELESS WANS and MANS**
	The cellular concept; call set-up; frequency reuse channel allocation algorithms; handoffs; mobility management. Telecommunication Systems: GSM and IS-95 architecture, channels and Call Establishment; Wireless Data Service; Generations in Wireless; DECT, TETRA, UMTS; Satellite Systems. WiMAX: physical layer, media access control, mobility and networking, overview of IEEE 802.22, Wireless, regional area networks. Wireless internet: address mobility; mobile IP; IP and TCP for wireless domains; WAP.

UNIT IV	**ADHOC WIRELESS NETWORKS**
	Introduction; applications design issues. MAC Protocols for Ad Hoc Wireless Networks: Issues, design goals and classification; Contention based protocols; Contention based mac protocols with reservation and scheduling mechanism; Other MAC Protocols. Cellular Networks and their features Routing Protocols for Ad Hoc Networks: Introduction, issues; classification; table-driven routing protocols; ondemand routing protocols; hybrid routing protocols; routing protocols with efficient flooding mechanisms; Hierarchical routing protocols.
UNIT V	**MULTICAST ROUTING IN AD HOC NETWORKS**
	Introduction; Issues; Operation of Multicast Routing Protocols; Classification; Tree-Based Multicast Routing Protocols; Mesh-Based Multicast Routing Protocols; Energy Efficient Multicasting. Energy Management in Ad Hoc Wireless Networks: Need and classification of energy management schemes. Transport layer for Ad Hoc Wireless Networks: Introduction and design issues; TCP over Ad Hoc wireless networks.

TEXTBOOKS

1. Andrew Troelsen,"Pro C and the .NET 4 Platform, Springer (India) Private Limited, New Delhi, India, 5th edition,2010.
2. Dharma Prakash Agrawal and Qing, a Zeng, introduction to Wireless and Mobile Systems, Tomson, 2006, 2nd edition, (ISBN: 0-534-49303-3).
3. Jochen Schiller: Mobile Communication

REFERENCE BOOKS:

1. David Tso Pramod Viswanath: Fundamentals of Wireless Communication, Cambridge University Press
2. Ezio Bigler: MIMO Wireless Communications, Cambridge University Press ARM Assembly Language, William Hohl, CRC Press, ISBN:978-81-89643-04-1.

WEB REFERENCES:

1. https://www.jntumaterials.co.in
2. http://www.inf.ed.ac.uk/teaching/courses/es/PDFs/WLAN.pdf
3. https://nptel.ac.in/courses/106108101/pdf
4. http://wwww.iare.ac.in

E-TEXT BOOKS:

1. http://www.bookzz.org/
2. http://www.jntubook.com
3. http://www.4shared.com/web/preview/pdf/BhrrT3m0

XVI COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
CONTENT DELIVERY (THEORY)			
1	Overview and applications,	CO1	T1:1.1
2	Types of wireless	CO1	T1:1.2
3	Mobile networks	CO1	T1:1.3
4	Evolution and challenges of wireless networks;	CO1	T1:1.4
5	The electromagnetic spectrum;	CO1	T1:1.5
6	Spread spectrum;	CO1	T1:1.6
7	Frequency reuse;	CO1	T1:1.7
8	Radio propagation mechanisms,	CO1	T1:1.8
9	Signals, antennas	CO1	T1:1.9
10	Characteristics of wireless channels	CO1	T1:1.10
11	Modulation techniques and	CO1	T1:1.11
12	Multiple access techniques for wireless systems	CO1	T1:1.12
13	Wireless LANs PANs:	CO2	T1:2.1
14	Use and design goals for WLANs;	CO2	T1:2.2
15	IEEE802.11 standard:	CO2	T1:2.3
16	Architecture, infrastructure	CO2	T1:2.4
17	Adhoc modes	CO2	T1:2.5
18	Physical MAC layer,	CO3	T1:2.6
19	CSMA/CA mechanism; HIPERLAN 1/2 standards; C	CO3	T1:2.7
20	Technical features of HOMERF;	CO2	T1:2.8
21	BLUETOOTH specifications and architecture;	CO3	T1:2.9
22	Introduction to other PAN technologies and their applications.	CO2	T1:2.10
23	PAN technologies	CO2	T1:2.11
24	The cellular concept;	CO2	T1:2.12
25	Call set-up	CO3	T1:5.3,
26	Frequency reuse channel allocation algorithms	CO3	T1:3.1
27	Handoffs	CO3	, T1:3.2

28	mobility management	CO3	T1:3.3
29	Telecommunication Systems	CO3	T1:3.4
30	GSM and IS-95 architecture	CO3	T1:3.4.1
31	Channels and Call Establishment	CO3	T1:3.5
32	Wireless Data Service;	CO3	T1:3.6
33	Generations in Wireless; DECT, TETRA, UMTS Satellite Systems	CO4	T1:3.7
34	WiMAX: physical layer	CO4	T1:3.8
35	Media access control	CO4	T1:3.9
36	Mobility and networking	CO4	T1:3.10
37	Overview of IEEE 802.22	CO4	T1:4.1
38	Wireless, regional area networks.	CO5	T1:4.2
39	Wireless internet: address mobility;	CO4	T1:4.3
40	Mobile IP; IP and TCP for wireless domains; WAP	CO4	T1:4.4
41	Introduction; applications design issues..	CO4	T1:4.5
42	MAC Protocols for Ad Hoc Wireless Networks:	CO4	T1:4.6
43	Issues, design goals and classification;	CO4	T1:4.7
44	Contention based protocols;	CO4	T1:4.8
45	Contention based mac protocols with reservation and	CO5	T1:4.9
46	Scheduling mechanism; Other MAC Protocols	CO5	T1:4.10
47	Cellular Networks and their features	CO5	T1:4.11
48	Routing Protocols for Ad Hoc Networks	CO5	T1:4.12
49	Introduction, issues	CO6	T1:5.2
50	Classification; table-driven routing protocols; on demand routing protocols;	CO6	T1:5.3
51	Hybrid routing protocols;	CO6	T1:5.4

52	Routing protocols with efficient flooding mechanisms	CO6	T1:5.5
53	Hierarchical routing protocols	CO6	T1:5.6
54	Operation of Multicast Routing Protocols; Classification; .	CO6	T1:5.7
55	Tree-Based Multicast Routing Protocols;	CO6	T1:5.8
56	Mesh-Based Multicast Routing Protocols; Energy Efficient Multicasting.	CO6	T1:5.9
57	Energy Management in Ad Hoc Wireless Networks:	CO6	T1:5.10
58	Need and classification of energy management schemes.	CO6	T1:5.11
59	Transport layer for Ad Hoc Wireless Networks:	CO6	T1:5.12
60	Introduction and design issues; TCP over Ad Hoc wireless networks	CO6	T1:5.13
DISCUSSION OF QUESTION BANK			
1	Unit – I: Fundamentals of wireless communication technology	CO1	T1:1.1-1.12
2	Unit– II: Wireless LANS and PANS	CO2	T1:2.1-2.13
3	Unit – III:Wireless WANS and WANS	CO3, CO4	T1:3.1-3.15,
4	Unit – IV: Adhoc wireless networks	CO5	T1:4.1-4.15
5	Unit – V: Multicast routing in adhoc networks	CO6	T1:5.1-5.14

Course Coordinator **HOD,ECE**

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING**(ES)				
Course Title	**INTERNET OF THINGS (IoT) APPLICATIONS LABORATORY**				
Course Code	BESD23				
Program	M. Tech				
Semester	II				
Course Type	Core				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Mr. CH Venkateswarluy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
B.Tech	-	-	Embedded C	-
B.Tech	-	-	Operating Systems	-

II COURSE OVERVIEW:

This course outlines the design and implementation of embedded systems using suitable hardware (ARM and PSOC) and Keil Embedded C software tools. The instruction set, Embedded C programming for I/O and memory interfacing techniques are covered. The hands-on experience acquired by the student's during the course makes them to carry out processor/controller-based projects and extend their knowledge on the latest trends and technologies in the field of embedded system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
NTERNET OF THINGS (IoT) APPLICATIONS LABORATOR	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

For practical courses there shall be a Continuous Internal Assessment (CIA) during the semester for 40 marks and 60 marks for semester end examination. Out of the 40 marks for internal evaluation:
1. A write-up on day-to-day experiment in the laboratory (in terms of Preparation / Performance in the laboratory / Calculations and graphs / Results and error analysis / Viva-voce) which shall be evaluated for 10 marks.
2. Viva-voce (or) tutorial (or) case study (or) application (or) poster presentation of the course concerned – 10 marks.

3. Internal practical examination conducted by the laboratory teacher concerned shall be evaluated for 10 marks.
4. The remaining 10 marks are for Laboratory Project, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.
5. The Semester End Examination shall be conducted with an external examiner and the laboratory teacher.
The external examiner shall be appointed from the cluster / other colleges which will be decided by the Principal.
The Semester End Examination held for 3 hours and total 60 marks are divided and allocated as shown below:
1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course
5. 10 marks for viva-voce on concerned laboratory course

VI Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 1: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 2: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
2	2	2	2	2	10

Table 3: Programming based

Objective	Analysis4	Design	Conclusion	Viva voce	Total
2	2	2	2	2	10

VII Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

VIII COURSE OBJECTIVES:

The students will try to learn:

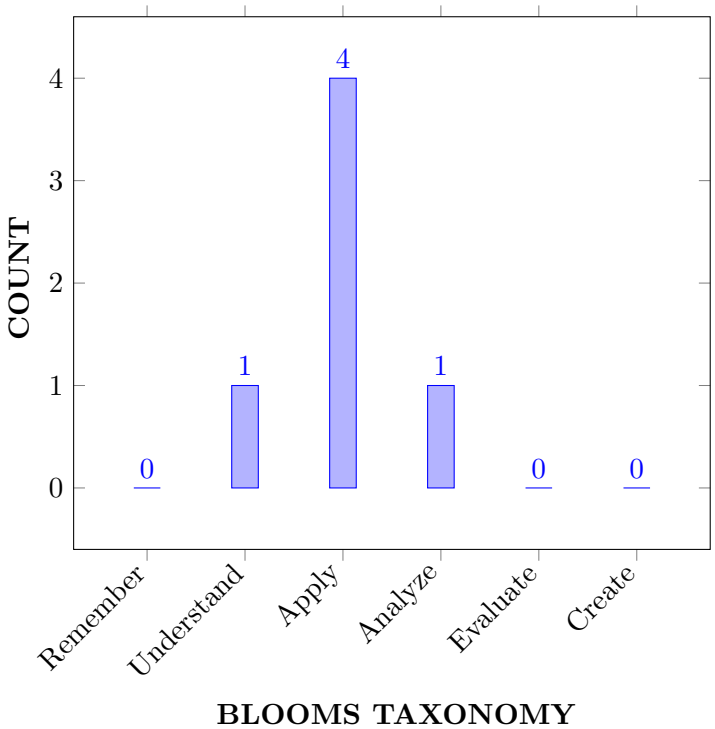
I	The IoT using Arduino programming.
II	The interfacing of data I/O devices with Arduino.
III	The design steps using Raspberry Pi.

IX COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the concept of Internet of Things for implementation of digital measuring devices	Apply
CO 2	**Develop** the Arduino programming for controlling lightning appliances.	Analyze
CO 3	**Analyze** the characteristics of Bluetooth modules for controlling the performance of appliances.	Apply
CO 4	**Make use of** direct and alternating type of electrical instruments using Arduino	Apply
CO 5	**Categorize** the protection schemes of induction motor against over current and under voltage.	Understand
CO 6	**Build** a relay model for protection of home appliances from over and under voltages.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



X PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

XI HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	3	CIE/SEE/AAT
PO 2	Write and present a substantial technical report / document	3	CIE/SEE/AAT
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program	2	CIE/SEE/AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	3	CIE/SEE/AAT

XII MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	✓	✓	✓	✓	-	-
CO2	✓	✓	-	✓	-	-
CO3	✓	✓	-	✓	-	-
CO4	✓	✓	✓	✓	-	-
CO5	✓	✓	✓	-	-	-
CO6	✓	✓	✓	-	-	-

XIII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Out-comes	PO'S	Justification for mapping (Students will be able to)	No. of Key competen-cies matched.
CO1	**PO 1**	Investigating various sensors and their applications in IoT involves research and **problem-solving**, requiring an in-depth understanding of how these sensors work. This will foster the ability to tackle **real-world IoT challenges** by applying **scientific principles and methodologies.**	**6**
	PO 2	After researching the sensor technologies and their applications, **documenting** and presenting findings requires the development of **technical writing and presentation skills**. This ensures clear communication of complex technical information to stakeholders, both in **written and oral** forms.	**4**
	PO 3	Mastery in understanding the different types of sensors used in IoT, along with their working principles and use cases, demonstrates a **higher level of expertise** in the field. The ability to apply this knowledge effectively shows a deep understanding beyond the basics, ensuring **comprehensive expertise** in the specialization.	**4**
	PO 4	Exploring sensor technologies in IoT applications equips learners to understand user needs and apply **scientific principles** to formulate and abstract real-world problems. It encourages **innovative thinking** for solution design, **experiment planning**, and effective use of resources like simulation tools, enabling deeper insight into embedded and robotic systems.	**5**
CO2	**PO 1**	Analyzing advanced sensors involves deep investigation into their evolving features and technological improvements. This develops the learner's ability to independently **research modern sensor capabilities** and apply them to solve accuracy and reliability issues in **real-world** industrial settings.	**6**
	PO 2	After researching the sensor technologies and their applications, **documenting and presenting** findings requires the development of technical **writing and presentation skills.** This ensures clear communication of complex technical information to stakeholders, both in **written and oral forms.**	**4**
	PO 4	Applies scientific principles to understand and integrate sensor technologies into embedded systems. Emphasizes **problem formulation and creative thinking** to develop **innovative**, sensor-based solutions. Involves managing the **design process and validating** system performance for effective use in IoT, healthcare, and communication domains.	**5**

CO3	**PO 1**	Understanding the architecture of wireless sensor systems involves identifying practical sensing **challenges and investigating** system modules to design effective solutions. Encourages independence, **self-driven** exploration, and the ability to implement and demonstrate functional wireless sensing setups with attention to quality and feasibility.	**5**
	PO 2	Demonstrating wireless sensor architecture involves not only technical understanding but also effective communication of the system's design, function, and integration. This requires clear **written documentation, proper referencing, and structured presentation**. Presenting insights from sensor system analysis reflects subject **knowledge, clarity, and communication skill**s—key to technical reporting.	**4**
	PO 4	Applying embedded system design concepts through problem **identification, experimentation, and solution development** using modern tools and methodologies. Encourages **innovation and scientific reasoning** to develop practical implementations for **real-world domains** such as IoT and communication. Reinforces the design, analysis, and validation of systems aligned with user needs and technological advancements.	**6**
CO4	**PO 1**	Understanding the operation of energy storage modules requires independence in conducting focused research. The ability to **identify problems** related to energy inefficiency and **implement solution**s in real-time scenarios reflects a **self-driven approach**. Demonstrating technical understanding in selecting and integrating modules also reflects the **quality of work** in addressing power reliability in wireless systems.	**6**
	PO 2	Exploring energy storage for wireless sensors involves effective **written communication and clarity in presentation** of technical concepts and configurations. Preparing structured documentation with **appropriate grammar and references** highlights the learner's subject knowledge and their ability to identify problems or opportunities in energy management for sensor networks.	**4**
	PO 3	Recognizing how energy storage systems enhance sensor reliability demonstrates knowledge and understanding of embedded applications. This includes **problem abstraction, use of creativity, and innovative design**. Mastery is shown through the design process, use of **modern tools, solution development, and validation** of the system's energy performance.	**5**

	PO 4	Energy storage integration into embedded systems showcases scientific principles, **problem-solving, and solution implementatio**n. Understanding user needs and applying **software tools or literature search methods** for optimal design reflects creativity and a deep grasp of IoT-based embedded applications. This competency supports **experimentation, evaluation, and project developmen**t in energy-aware system design.	**5**
CO5	**PO 1**	Understanding the NEST sensor ecosystem encourages independent investigation into energy-efficient technologies. It involves **problem identification and implementation** of intelligent home automation systems. The analysis and integration of such ecosystems reflect a **self-driven mindset and quality of work** in addressing real-world energy and automation challenges.	**6**
	PO 2	IDescribing the NEST ecosystem's working requires **clear written communication, structured presentation**, and proper referencing of smart home technologies. Presenting its functionality and benefits showcases clarity, strong subject knowledge, and an ability to identify opportunities in energy-efficient design.	**3**
	PO 3	Explaining the NEST sensor system showcases knowledge and understanding of intelligent embedded systems in real-time applications. It involves **problem abstraction, innovative product design, and the use of modern tools for solution development, evaluation**, and result validation—all demonstrating a higher level of mastery in the domain of smart technologie	**5**
CO6	**PO 1**	Understanding how hardware components interact requires identifying implementation-level challenges and exploring how to resolve them using platform-specific strategies. This develops **problem identification, quality of work, and self-driven investigation** needed in embedded system tasks.	**5**
	PO 2	Explaining communication protocols, circuit integration, and hardware programming principles strengthens the ability to **document processes, clarify design logic, and effectively present technical solutions** in embedded applications.	**4**
	PO 3	Mastery of embedded hardware interaction indicates deep knowledge, **innovative thinking, and the ability to design and implement hardware-software systems** that go beyond basic undergraduate expectations.	**5**

Note: For Key Attributes refer **Annexure - I**

XIV TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

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COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	6	4	4	5	-	-
CO 2	6	4	-	5	-	-
CO 3	5	4	-	6	-	-
CO 4	6	4	5	5	-	-
CO 5	6	3	5	-	-	-
CO 6	5	4	5	-	-	-

XV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	100	66.6	44.4	50	-	-
CO 2	100	66.6	-	50	-	-
CO 3	83.3	66.6	-	60	-	-
CO 4	100	66.6	55.5	60	-	-
CO 5	100	50	55.5	-	-	-
CO 6	83.33	66.66	55.5	-	-	-

XVI COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 - 0 ≤ C≤ 5% – No correlation

1 -5 <C≤ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	2	2	-	-
CO 2	3	3	-	2	-	-
CO 3	3	3	-	3	-	-
CO 4	3	3	2	3	-	-
CO 5	3	2	2	-	-	-
CO 6	3	3	2	-	-	-
TOTAL	**18**	**17**	**8**	**10**	**-**	**-**
AVERAGE	**3**	**2.8**	**2**	**2.5**	**-**	**-**

XVII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
Quiz	-	Tech - Talk	-	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	✓	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XIX SYLLABUS:

WEEK I	**IOT WITH ARDUINO PROGRAMMING**
	Introduction to Internet of Things (IoT) using Arduino programming
WEEK II	**CONROLLING RGB LED**
	Programming for Controlling RGB LED using Arduino and Wi-Fi Module
WEEK III	**IOT TO CONTROL REMOTE LED**
	Programming for Internet of things with Android and Arduino. Build an Arduino IoT to control a remote LED
WEEK IV	**INTERFACING BLUETOOTH MODULE**
	Programming for how to interface HC-05 Bluetooth Module with Arduino UNO for various application
WEEK V	**INTERFACING TO TEMPERATURE SENSOR**
	Programming to Interface Temperature sensor and Monitoring using IoT with Arduino Uno and display digital value on LCD.
WEEK VI	**INTERFCAING IR SENSOR**
	Programming to Interface IR sensors and blue tooth for detecting obstacle using Arduino with android Application.
WEEK VII	**TRACK LOCATION**
	Programming for Node MCU for track location without using GPS module.
WEEK VIII	**SEND DATA FROM ARDUINO TO WEB PAGE**
	Programming for how to send data from Arduino to Webpage using Wi-Fi module.
WEEK IX	**IOT WITH RASBERRY PI**
	Introduction to Internet of things (IoT) by using a Raspberry Pi to connect devices.
WEEK X	**SETUP WI-FI ON RASBERRY PI USING USB**
	Programming for how to Setup Wi-Fi on Raspberry Pi 2 using USB Dongle.
WEEK XI	**INTERFACE TO MOTION SENSOR**
	Programming to interface a motion sensor to use GPIO pins with a Raspberry Pi.
WEEK XII	**INTERFACE TO GAS SENSOR**

	Programming to interface Gas sensor for detection and monitoring using Arduino and IoT.
WEEK XIII	**INTERFACE TO SOIL MOSITURE SENSOR WITH NODE**
	Programming to interface soil moisture sensor with a node and irrigates plant automatically.
WEEK XIV	**INTERFACE TO SOLENOID VALVE WITH NODE**
	Programming to interface solenoid valve actuator for real time applications.

REFERENCE BOOKS:

1. Mark Torvalds, "Arduino Programming: Step-by-step guide to mastering Arduino hardware and software (Arduino, Arduino projects, Arduino uno, Arduino starter kit, Arduino ide, Arduino yun, Arduino mega, Arduino nano) Kindle Edition, 2nd Edition, 2009.

2. Michael J. Pont, "Embedded C", Pearson Education, 2nd Edition, 2008.

XX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	IOT WITH ARDUINO PROGRAMMING Introduction to Internet of Things (IoT) using Arduino programming	CO 1	T1:1.1,1.2
2	CONROLLING RGB LED Programming for Controlling RGB LED using Arduino and Wi-Fi Module	CO 2	T1:1.3,1.6
3	IOT TO CONTROL REMOTE LED Programming for Internet of things with Android and Arduino. Build an Arduino IoT to control a remote LED	CO 3	T1:9,1.12
4	INTERFACING BLUETOOTH MODULE Programming for how to interface HC-05 Bluetooth Module with Arduino UNO for various application	CO 4	T1:17.1,1.23
5	INTERFACING TO TEMPERATURE SENSOR Programming to Interface Temperature sensor and Monitoring using IoT with Arduino Uno and display digital value on LCD.	CO 4	T2:11.1,1.8
6	INTERFCAING IR SENSOR Programming to Interface IR sensors and blue tooth for detecting obstacle using Arduino with android Application.	CO4	T2:10.1,10.4
7	TRACK LOCATION Programming for Node MCU for track location without using GPS module.	CO 4	T2:11.2-11.4
8	SEND DATA FROM ARDUINO TO WEB PAGE Programming for how to send data from Arduino to Webpage using Wi-Fi module.	CO 5	T2:9.1,1.6
9	IOT WITH RASBERRY PI Introduction to Internet of things (IoT) by using a Raspberry Pi to connect devices.	CO 5	T2:10.2-11.4
10	SETUP WI-FI ON RASBERRY PI USING USB Programming for how to Setup Wi-Fi on Raspberry Pi 2 using USB Dongle.	CO 5	T2:9.2-11.4
11	INTERFACE TO MOTION SENSOR Programming to interface a motion sensor to use GPIO pins with a Raspberry Pi.	CO 6	T1:12,1.9

12	INTERFACE TO GAS SENSOR Programming to interface Gas sensor for detection and monitoring using Arduino and IoT.	CO 6	T2:1.1,1.5
13	INTERFACE TO SOIL MOSITURE SENSOR WITH NODE Programming to interface soil moisture sensor with a node and irrigates plant automatically.	CO 6	T2:8.2-11.4
14	INTERFACE TO SOLENOID VALVE WITH NODE Programming to interface solenoid valve actuator for real time applications.	CO 6	T2:13.2-11.4

Signature of Course Coordinator
Mr. CH Venkateswarlu, Assistant Professor

HOD, ECE

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven 3. Quality of work 4. Problem identification and implementation 5. Demonstrate the solutions 6. Budget	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing report	6
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2. Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5. Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation	9
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	10

PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	7
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1. Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	8

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
COURSE DESCRIPTION

Department	**Electronics and Communication Engineeringy(ES)**				
Course Title	**ARM Cortex Architecture and Programming Laboratory**				
Course Code	BESD24				
Program	M.Tech				
Semester	II				
Course Type	Laboratory				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Dr.S.China Venkateswarlu, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	Embedded C

II COURSE OVERVIEW:

This laboratory course is designed to provide students with practical experience in designing and implementing ARM Cortex Architecture and Programming Laboratory. The following experiments are to be performed on ARM Cortex- M TM4C123 Microcontroller using Embedded C.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Cyber Security Laboratory	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during

day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 1: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

Continuous Internal Examination (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 2: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Table 3: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Semester End Examination:
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

VI COURSE OBJECTIVES:

The students will try to learn:

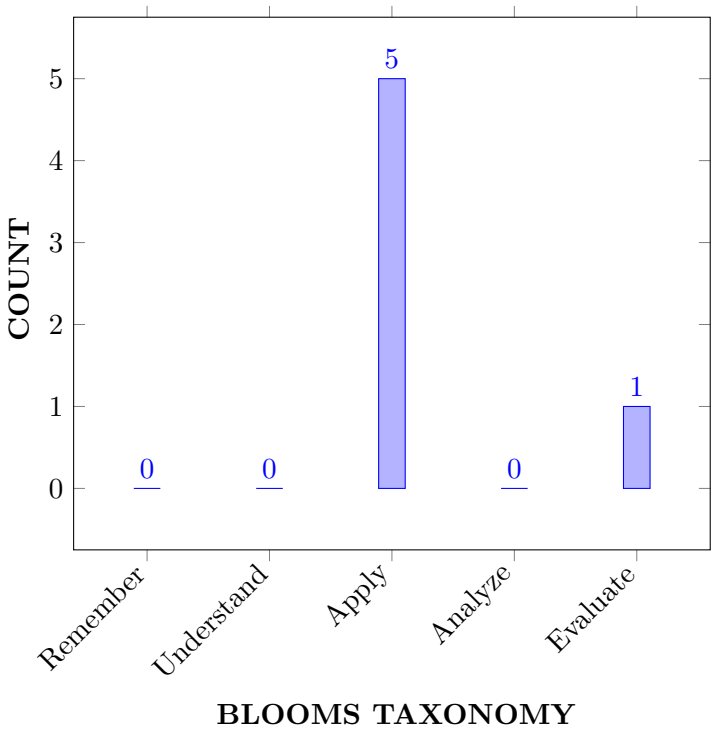
I	Writing embedded C programs for ARM microcontrollers.
II	Using Sy stick counter of ARM microcontrollers.
III	Programming the interrupts of ARM microcontrollers.
IV	Interfacing sensors with ARM microcontrollers.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** ARM Microcontroller for analyzing the response of ARM performance levels based on Embedded C .	Apply
CO 2	**Apply for** transmit receive data using UART using Embedded C verifying transmitting and receiving data analysis.	Apply
CO 3	**Develop** for delay functions using timers using Embedded C ARM Microcontroller.	Apply
CO 4	**Compare** for Interfacing Sensors with ARM Microcontroller using Embedded C Programs.	Evaluate
CO 5	**Build** Embedded Systems with ARM Cortex M4 using with powered STM32 Microcontroller.	Apply
CO 6	**Apply** Apply to Interpret the content of a message received through UART for learn how to interpret the message and analyze with ARM Cortex.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research/investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report/document.

Program Outcomes	
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve real-time problems with advanced-level knowledge, techniques, skills, and modern tools in computer science thrust areas.
PO 5	Function effectively in multidisciplinary environments with the knowledge of frontier technologies by working cooperatively, creatively, and responsively as a member or leader in diverse teams.
PO 6	Engage in life-long learning for continuing education in doctoral-level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO1	Independently carry out research / investigation and development work to solve practical problems	2	Laboratory practices, student viva
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	2	Laboratory Practices, student viva
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications	3	Laboratory Practices, Mini-Project

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	✓	✓	✓	✓	-	-
CO2	✓	✓	-	✓	-	-
CO3	✓	✓	-	✓	-	-
CO4	✓	✓	✓	✓	-	-
CO5	✓	✓	✓	-	-	-
CO6	✓	✓	✓	-	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Out-comes	PO'S	Justification for mapping (Students will be able to)	No. of Key competen-cies matched.
CO1	**PO 1**	Applying Embedded C to program ARM Cortex microcontrollers and **problem-solving**, for sensor-based applications requires strong foundational knowledge in electronics **microcontrollers, and sensor technologies** by applying **scientific principles and methodologies.**	**6**
	PO 2	Investigating various sensors and their behavior in IoT contexts requires students to identify, formulate and their applications, **documenting** and embedded system challenges, such as data acquisition accuracy, power consumption, or sensor interfacing. **technical writing and presentation skills**. This ensures clear communication of complex technical information to stakeholders, both in **written and oral** forms.	**4**
	PO 3	sensor-based Embedded C programs on ARM Cortex boards to design real-time monitoring **higher level of expertise** in the field. The ability to apply this knowledge effectively shows a deep understanding beyond the basics, automation systems, showing competency in developing practical embedded IoT solutions. **comprehensive expertise** in the specialization.	**4**
	PO 4	Exploring Embedded systems technologies in Real time applications equips learners to understand user needs and apply **scientific principles** to formulate and abstract real-world problems. It encourages **innovative thinking** for solution design, **experiment planning**, and various sensor interfacing libraries cultivates proficiency with modern embedded .	**5**
CO2	**PO 1**	fundamental knowledge of digital communication, microcontroller architecture, and Embedded C programming to configure and **research modern sensor capabilities** operate UART (Universal Asynchronous Receiver/Transmitter) for serial data transmission and reception **real-world** This involves understanding baud rates, data frames, and register-level programming on ARM Cortex boards.	**6**
	PO 2	Analyzing the correctness and integrity of transmitted **documenting and presenting** and received data requires students to interpret system behavior **writing and presentation skills.** debug communication errors, and ensure data synchronization-developing analytical and diagnostic skills in embedded systems. **written and oral forms.**	**4**

	PO 4	Verifying UART communication involves setting up test scenarios **problem formulation and creative thinking** to develop **innovative**, using tools like serial terminals and logic analyzers, and interpreting the timing and data flow for communication protocols. **design process and validating** This fosters investigative thinking and experimental validation of embedded communication systems.	**5**
CO3	**PO 1**	Developing timer-based delay functions involves applying knowledge of microcontroller architecture, **challenges and investigating** clock systems, and timer/counter modules. Students use Embedded C to access **self-driven** and configure ARM Cortex registers, reinforcing their understanding of hardware-software integration.	**5**
	PO 2	Creating accurate delays requires students to analyze timing requirements **written documentation, proper referencing, and structured presentation**. understand clock frequencies, and debug mismatches in expected versus actual behavior. **knowledge, clarity, and communication skill**They must analyze system responses and correct timing errors, which builds their analytical problem-solving ability.	**4**
	PO 4	Implementing and verifying precise delays involves experimentation, measurement, **identification, experimentation, and solution development** and calibration using timers. Students conduct investigations by varying parameters **innovation and scientific reasoning** observing behavior via debugging tools (like LEDs, oscilloscopes, or serial outputs), **real-world domains** and refining their implementation for reliable results.	**6**
CO4	**PO 1**	Interfacing sensors with ARM microcontrollers requires applying core concepts of electronics, signal processing **identify problems** and microcontroller programming. Students must understand sensor **implement solution**s in real-time scenarios reflects a **self-driven approach**. characteristics (analog/digital), GPIO control, ADC **quality of work**usage, and Embedded C coding to extract meaningful data.	**6**
	PO 2	Analyzing the behavior of different sensors under varying conditions **written communication and clarity in presentation** and resolving issues related to signal noise, accuracy, **appropriate grammar and references** and responsiveness requires identifying and interpreting real-world system problems and troubleshooting them effectively.	**4**

	PO 3	develop and compare Embedded C programs to interface multiple sensors e.g., temperature, IR, ultrasonic, etc. **problem abstraction, use of creativity, and innovative design**. for ARM-based applications. This involves creating efficient code **modern tools, solution development, and validation**and system setups to meet specific application needs, demonstrating design thinking and practical implementation skills.	**5**
	PO 4	Comparing different sensor interfaces involves setting up experiments **problem-solving, and solution implementatio**collecting and analyzing sensor data, **software tools or literature search methods** and evaluating system performance. Students investigate timing, accuracy, **experimentation, evaluation, and project developmen**and communication protocols (e.g., I2C, SPI), fostering systematic inquiry and critical evaluation.	**5**
CO5	**PO 1**	uilding embedded systems using the STM32 -ARM Cortex-M4 platform requires **problem identification and implementation** applying knowledge of embedded architectures, digital electronics, peripheral interfacing, **self-driven mindset and quality of work** and Embedded C programming. Students utilize core engineering principles to integrate hardware and software effectively.	**6**
	PO 2	Designing and implementing embedded systems on STM32 involves identifying system requirements, **clear written communication, structured presentation**, analyzing constraints (such as memory, speed, and power), and troubleshooting hardware-software integration issues. This sharpens analytical and problem-solving abilities in embedded design.	**3**
	PO 3	This CO challenges students to architect complete embedded solutions **problem abstraction, innovative product design, and the use of modern tools for solution development, evaluation**, from writing peripheral drivers to integrating sensor data and control logic—demonstrating design and development capabilities in real-world embedded applications.	**5**
CO6	**PO 1**	Interpreting UART messages involves applying core knowledge of communication protocols, data encoding, ARM Cortex architecture, **problem identification, quality of work, and self-driven investigation** and Embedded C programming. Students learn how UART buffers and registers work to extract meaningful information from raw byte streams.	**5**

	PO 2	Analyzing the structure, correctness, and purpose of received messages requires identifying possible data corruption, framing errors, **document processes, clarify design logic, and effectively present technical solutions** or synchronization issues, and applying systematic debugging techniques to ensure communication reliability.	**4**
	PO 3	Developing logic to parse and respond to UART messages using ARM Cortex microcontrollers enables students to build interactive systems. **innovative thinking, and the ability to design and implement hardware-software systems** This demonstrates the ability to design robust communication-based solutions, such as command interpreters or sensor gateways.	**5**

Note: For Key Attributes refer **Annexure - I**

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

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COURSE OUTCOMES	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	6	4	4	5	-	-
CO 2	6	4	-	5	-	-
CO 3	5	4	-	6	-	-
CO 4	6	4	5	5	-	-
CO 5	6	3	5	-	-	-
CO 6	5	4	5	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	100	66.6	44.4	50	-	-
CO 2	100	66.6	-	50	-	-
CO 3	83.3	66.6	-	60	-	-
CO 4	100	66.6	55.5	60	-	-
CO 5	100	50	55.5	-	-	-
CO 6	83.33	66.66	55.5	-	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 - 0 ≤ C≤ 5% – No correlation
1 -5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	**PROGRAM OUTCOMES**					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	2	2	-	-
CO 2	3	3	-	2	-	-
CO 3	3	3	-	3	-	-
CO 4	3	3	2	3	-	-
CO 5	3	2	2	-	-	-
CO 6	3	3	2	-	-	-
TOTAL	**18**	**17**	**8**	**10**	**-**	**-**
AVERAGE	**3**	**2.8**	**2**	**2.5**	**-**	**-**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVII SYLLABUS:

WEEK I	**INTRODUCTION TO ARM CORTEX-M TM4C123 MICROCONTROLLER USING EMBEDDED C**
	Reading switches and displaying on LEDs.
WEEK II	**ARM CORTEX-M TM4C123 MICROCONTROLLER USING EMBEDDED C**
	Initializing and displaying message on LCD display.
WEEK III	**TRANSMITTING DATA USING UART**
	Transmitting data using UART.
WEEK IV	**RECEIVING DATA USING UART**
	Receiving data.
WEEK V	**TOGGLING LED USING SYS TICK COUNTER**
	Toggling LED .
WEEK VI	**IMPLEMENTING DELAY FUNCTION USING TIMERS**
	Implementing delay function using Timers

WEEK VII	**USING GPIOF INTERRUPT**
	Using GPIOF interrupt.
WEEK VIII	**USING SYS TICK INTERRUPT**
	Using Sys Tick interrupt.
WEEK IX	**INTERRUPT PRIORITY DEMONSTRATION**
	Interrupt priority demonstration
WEEK X	**INTERFACING LM34 TEMPERATURE SENSOR**
	Implementation of Rabin Cryptosystem
WEEK XI	**COMMUNICATING WITH REAL TIME CLOCK USING I2C**
	Communicating with Real time clock using I2C.
WEEK XII	**USING PWM MODULE TO CONTROL LED INTENSITY**
	Using PWM module to control LED intensity.
WEEK XIII	**AUTOMATIC CA R PARKING SYSTEM USING ARM**
	An automa Design and implement tic car parking system using ARM.
WEEK XIV	**OBJECT DETECTION USING ARM**
	Design and implement an object detection using IR Sensor using ARM

TEXTBOOKS

1. 1. Microcontroller Based Embedded Systems Laboratory Manual, Author: Steve Furber,
2. Penetration Testing: ARM System on Chip Architecture, 2 nd edition, New Delhi: Dorling Kindersley (India) Pvt. Ltd., 2000.

   Author: Georgia Weidman

REFERENCE BOOKS:

1. 1. Muhammad Ali Mazidi, Shujen Chen, Sarmad Naimi, Sepehr Naimi, TI ARM.(Applications and Standards) by William Stallings Pearson Education.
2. Jonathan Valvano, Embedded Systems: Real-Time Operating Systems for Arm Cortex Microcontrollers, Charleston: Create Space Independent Publishing Platform, 2012

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	INTRODUCTION TO ARM CORTEX-M TM4C123 MICROCONTROLLER USING EMBEDDED C: Reading switches and displaying on LEDs.	CO 1	T1:1.1,1.2
2	ARM CORTEX-M TM4C123 MICROCONTROLLER USING EMBEDDED C: Initializing and displaying message on LCD display	CO 2	T1:1.3,1.6
3	TRANSMITTING DATA USING UART: Transmitting data using UART	CO 3	T1:9,1.12

4	RECEIVING DATA USING UART: Receiving data.	CO 4	T1:17.1,1.23
5	TOGGLING LED USING SYS TICK COUNTER: Toggling LED	CO 4	T2:11.1,1.8
6	IMPLEMENTING DELAY FUNCTION USING TIMERS: Implementing delay function using Timers .	CO4	T2:10.1,10.4
7	USING GPIOF INTERRUPT: Using GPIOF interrupt	CO 4	T2:11.2-11.4
8	USING SYS TICK INTERRUPT: Using Sys Tick interrupt .	CO 5	T2:9.1,1.6
9	INTERRUPT PRIORITY DEMONSTRATION: Interrupt priority demonstration.	CO 5	T2:10.2-11.4
10	INTERFACING LM34 TEMPERATURE SENSOR: Interfacing LM34 temperature sensor	CO 5	T2:9.2-11.4
11	COMMUNICATING WITH REAL TIME CLOCK USING I2C: Communicating with Real time clock using I2C.	CO 6	T1:12,1.9
12	USING PWM MODULE TO CONTROL LED INTENSITY: Using PWM module to control LED intensity.	CO 6	T2:1.1,1.5
13	AUTOMATIC CA R PARKING SYSTEM USING ARM: An automa Design and implement tic car parking system using ARM.	CO 6	T2:8.2-11.4
14	OBJECT DETECTION USING ARM: Design and implement an object detection using IR Sensor using ARM	CO 5	T2:13.2-11.4

XIX EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design register usage in ARM Cortex processors and have them write assembly code to perform basic operations using registers.
2	Develop Simulate interrupt scenarios (e.g., timer interrupts, external interrupts) and guide students to write interrupt service routines (ISRs) in assembly or C.
3	Interface ARM Cortex processors with peripherals (e.g., GPIO, UART) and have students write code to control and communicate with these peripherals.
4	Design Vocoders (voice coder) to reduce the bandwidth requirements of normal voice signal using analysis-synthesis sections.
5	Noise removal: Add noise above 3 KHz and then remove interference suppression using 400 Hz tone.

Signature of Course Coordinator **HOD,ECE**
Dr.S.China Venkateswarlu, Professor

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING(ES)**				
Course Title	**Embedded Systems for Automative Applications**				
Course Code	BESD26				
Program	M.Tech				
Semester	III				
Course Type	Professional Elective -V				
Regulation	MT-23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	J Swetha Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
M.Tech	BESD01	I	Embedded System Programming
M.Tech	BESD02	I	Microcontroller and Programmable Digital Signal Processing

II COURSE OVERVIEW:

This course aims to provide students with a solid foundation in embedded systems for automative application. Students will learn about robotic applications, which have had a profound impact on almost all our modern technology such as video cameras, computing machinery, smartphones, digital display systems, and so on. Embedded systems are used to control and monitor various safety features of a vehicle, including airbags, seat belts, and anti-lock braking systems. These systems work together to ensure that the driver and passengers are safe in the event of an accident.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Embedded Systems for Automative Applications	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	**x**	MOOC
x	Open Ended Experiments	✓	Seminars	**x**	Mini Project	**x**	Videos
x	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50%	To test the objectiveness of the concept
30%	To test the analytical skill of the concept
20%	To test the application skill of the concept

Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted. CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Assignment / Quiz and 10 marks for Alternative Assessment Tool (AAT). Two CIE examinations are Compulsory and sum of the two exams, along with the scores obtained in the assignment / Quiz and AAT shall be considered for computing the final CIA of a student in a given course. Advance notification for the conduction of Assignment / Quiz / AAT is mandatory and the uploading and conduction is lies with the office of planning, monitoring and continuing studies.

Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIE-1	CIE-2	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Assignment / Quiz	5 Marks	5 Marks		10 Marks
Alternative Assessment Tool (AAT)	5 marks	5 marks		10 marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:

The assignments develop different skills and increase their knowledge base significantly. It provides the evidence for the faculty that the students have achieved the goals. It helps the faculty to evaluate the student's understanding of the course. Assignment will be evaluated for 5 marks. The assignment has to either handwritten / typed and uploaded to the Samvidha portal at the end of either CIE1 or CIE2, based on the questions provided by the course coordinator for that semester.

Quiz:

It is online proctor based online examination conducted either at the end of the CIE1 or CIE2.

Alternative Assessment Tool (AAT):
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. The AAT may include tech talk, case studies, seminars, term paper, open ended experiments, partial reproduction of research work, oral presentation of research work, developing a generic tool-box for problem solving, report based on participation in create-a-thon, makea-thon, code-a-thon, hack-a-thon conducted by reputed organizations / any other. etc.

VI COURSE OBJECTIVES:

The students will try to learn:

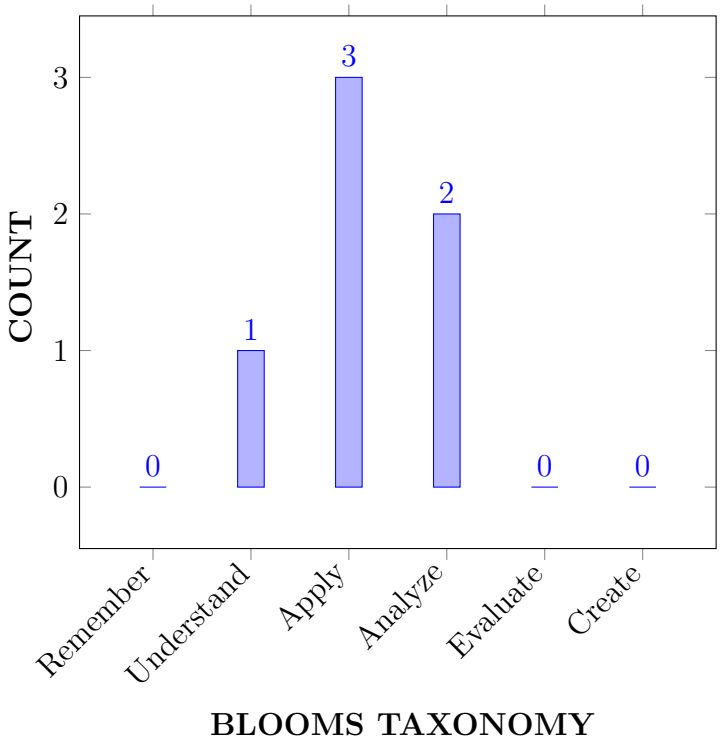
I	The fundamental knowledge of the Automotive applications.
II	Obtain knowledge and their working of Embedded systems control and monitor various safety features of a vehicle principles.
III	Identify the various areas of application for inclusion of Embedded systems.

VII COURSE OUTCOMES:

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

CO 1	**Develop** programming skills in embedded systems for various applications.	Understand
CO 2	**Identify** the knowledge about the Life cycle of embedded design and its testing.	Apply
CO 3	**Analyze** the knowledge about programming and system control to perform a specific task.	Analyze
CO 4	**Illustrate** the principle and characteristics of automotive applications to simulate using tools.	Apply
CO 5	**Select** the Life cycle used in Embedded Systems.	Analyze
CO 6	**Make use of** modern embedded systems to design and implement the various applications.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	2	SEE/CIE/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	3	SEE/CIE/AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications.	1	SEE/CIE/AAT
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	3	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	-	✓	✓	-	✓
CO 2	✓	-	-	✓	-	✓
CO 3	✓	-	✓	✓	-	-
CO 4	✓	-	✓	✓	-	-
CO 5	✓	-	-	-	-	✓
CO 6	✓	-	✓	✓	-	✓

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Understand the embedded systems, with emphasis on how they differ from **general-purpose systems**. Introducing the **design flow** and processor-based **architecture** helps students conceptualize how **automotive** ECUs are develope	4
	PO 3	Demonstrate the importance of embedded technologies and design new **innovative** products using embedded system programming for solving society **relevant problems** for applying knowledge, understanding and **demonstrations** of embedded applications in real time scenario.	3
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using **Scientific principles** and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and **understand both hardware** and **software aspects** early ensures students are equipped for system-level thinking crucial for solving real-world automotive problems.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 6	Recognize the need to engage in **lifelong learning** through continuing education and **research for strengthen in embedded and advanced engineering** areas.	3
CO 2	PO 1	Understand the **hardware knowledge**, allowing students to understand the **architectural design** of embedded platforms—a core skill in developing automotive controllers. Concepts like bus timing, **memory management, and processor performance** are vital for **optimizing system speed, cost, and power** key trade-offs in automotive systems.	5
	PO 4	Applying embedded system design concepts through problem identification, **experimentation**, and solution development using **modern tools** and **methodologies**. Encourages innovation and scientific reasoning to develop practical implementations for real-world domains.	4
	PO 6	Recognize the need to engage in **lifelong learning** through continuing education and **research for strengthen in embedded and advanced engineering**	3
CO 3	PO 1	Understand the knowledge of how device drivers act as **intermediaries** between **hardware and software**, enabling embedded systems to interact with external devices efficiently. In automotive applications, for example, **interrupt handling and real-time data** processing are crucial for **safety-critical systems** like airbags or ABS (Anti-lock Braking Systems).	4
	PO 3	Designing memory and **I/O device drivers** ensures students understand the intricacies of **system-level programming**. Understanding **on-board bus device drivers and board I/O drivers helps** students optimize performance in systems with strict power and time constraints, which is common in embedded automotive control systems.	5
	PO 4	Demonstrate the importance of **embedded technologies** and design new innovative products for solving society relevant problems for **applying knowledge, understanding** and demonstrations of embedded applications in real time scenario and use creativity to establish **innovative solutions** and manage the **design process** and evaluate outcomes using**modern tools**	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 1	**Understanding the operation** of energy storage modules requires independence in **conducting focused research**. The ability to identify problems related to energy **inefficiency and implement solutions** in real-time scenarios reflects a **self-driven approach**. Demonstrating technical understanding in selecting and integrating modules also reflects the quality of work in addressing power reliability in wireless systems.	6
	PO 3	**Demonstrate a degree of mastery over the area** as per the **specialization of the program**. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	3
	PO 4	Understanding the **energy storage for automotive sensors involves** effective written communication and clarity in presentation of technical concepts and configurations. **Preparing structured documentation** with appropriate grammar and references **highlights the learner's subject knowledge** and their ability to **identify problems or opportunities in energy** management for sensor networks.	5
CO 5	PO 1	**Independently carry out research** / investigation and **development work to solve practical problems**.strengthen in embedded and advanced engineering areas.	3
	PO 6	Recognize the need to engage in **lifelong learning** through continuing education and **research for strengthen in embedded and advanced engineering**	5
CO 6	PO 1	Independently carry out research / investigation and development work to solve practical problems.Apply the concepts (knowledge) of embedded systems using their **architectures by using Scientific principles and methodology**and problem formulation and **abstraction** for understand the need of users with the **importance** of considerations such as IoT and Robotics	4
	PO 3	Demonstrating **automotive sensor architecture** involves not only technical understanding but also **effective communication** of the system's design, function, and integration. This requires clear written documentation, **proper referencing**, and structured presentation. Presenting insights from sensor system analysis reflects subject knowledge, clarity, and **communication skills**key to technical reporting	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	Understanding how **hardware components interact requires identifying** implementation-level challenges and exploring how to resolve them using **platform-specific strategies**. This develops problem **identification, quality of work**, and self-driven investigation needed in embedded system tasks.	5
	PO 6	Recognize the need to engage in **lifelong learning** through continuing education and **research for strengthen in embedded and advanced engineering**	3

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	4	-	3	3	-	3
CO 2	5	-	-	4	-	3
CO 3	4	-	5	6	-	-
CO 4	6	-	3	5	-	-
CO 5	3	-	-	-	-	5
CO 6	4	-	6	5	-	3

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 10	PO 12
	6	6	9	10	7	8
CO 1	66.6	-	33.3	30	-	37.5
CO 2	83.3	-	-	40	-	37.5
CO 3	66.6	-	55.5	60	-	-
CO 4	100	-	33.3	50	-	-
CO 5	50	-	-	-	-	62.5
CO 6	66.6	-	66.6	50	-	37.5

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6

CO 1	3	-	1	1	-	1
CO 2	3	-	-	2	-	1
CO 3	3	-	2	3	-	-
CO 4	3	-	2	2	-	-
CO 5	2	-	-	-	-	3
CO 6	3	-	3	2	-	1
TOTAL	**17**	**-**	**8**	**10**	**-**	**6**
AVERAGE	**2.8**	**-**	**2**	**2**	**-**	**1.5**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	-	Tech - Talk	✓	Certification	-
Term Paper	-	Seminars	✓	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVII SYLLABUS:

MODULE I	**INTRODUCTION**
	An embedded system-definition, examples, current technologies, integration in system design, embedded system design flow, hardware design concepts, software development, processor in an embedded system and other hardware units, introduction to processor based embedded system design concepts.
MODULE II	**EMBEDDED HARDWARE**
	Embedded hardware building blocks, embedded processors, ISA architecture models, internal processor design, processor performance, board memory ROM, RAM, auxiliary memory, memory management of external memory, board memory and performance. embedded board input / output, serial versus parallel I/O, interfacing the I/O components, I/O 73 — P a g e components and performance, board buses, bus arbitration and timing, integrating the bus with other board components, bus performance.
MODULE III	**EMBEDDED SOFTWARE**

	Device drivers, device drivers for interrupt-handling, memory device drivers, on-board bus device drivers, board I/O drivers, explanation about above drivers with suitable examples. embedded operating systems, multitasking and process management, memory management, I/O and file system management. OS standards example, POSIX OS performance guidelines, board support packages, middleware and application software, middle Ware examples, application layer software examples.
MODULE IV	**AUTOMOTIVE SYSTEMS OVERVIEW**
	Automotive vehicle technology, overview of vehicle categories, various vehicle sub systems like chassis, body, driveline, engine technology, fueling technology, vehicle emission, brakes, suspension, emission, doors, dashboard instruments, wiring harness, safety ,security, comfort and infotainment, communication , lighting, future trends in automotive embedded systems.
MODULE V	**AUTOMOTIVE SENSORY SYSTEM**
	Automotive sensors and transducers: temperature, manifold and barometric pressures, humidity, carbon dioxide (CO2), carbon Monoxide (CO), oxygen (O2) Sensors, proximity distance sensors, engine speed sensors, throttle position sensors, pressure sensors, knock Sensor , Mass flow sensor.

TEXTBOOKS

1. Thomas Braun, "Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems", 3rd edition, springer-Verlag Berlin Heidelberg, 2008..
2. Saeed B Niku, (2019), introduction to Robotics, analysis, control and applications, Wiley Publications. ISBN: 978-1-119-52760-2.
3. R.K. Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, 1 st edition, 2003..

REFERENCE BOOKS:

1. William B. Ribbens, "Understanding Automotive Electronics, an Engineering Perspective", seventh edition, butter worth-Heinemann Publications.
2. Ronald K. Jurgen, "Automotive Electronics Handbook", Mc-Graw Hill.
3. Kinckle, Uwe, Nielsen Lars, "Automotive Control Systems for Engine, Driveline, and Vehicle", 2nd edition, springer publication

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	https://lms.iare.ac.in/index?route=course/details
CONTENT DELIVERY (THEORY)			
2	Pre requisites	CO1	T1-3.1-3.2

3	An embedded system-definition and examples	CO1	T1-3.3-3.4
4	Current technologies, integration in system design	CO1	T1-3.3-3.4
5	Embedded system design flow	CO1	T1-3.7
6	Hardware design concepts	CO1	T1-3.5
7	Software development	CO1	T1-3.6
8	Processor in an embedded system and other hardware units	CO2	T1-5.1.1
9	Introduction to processor based embedded system design concepts	CO2	T1-.1.1,5.1.2
10	Embedded hardware building blocks, embedded processors, ISA architecture models	CO2	T1-5.2
11	internal processor design, processor performance	CO2	T1-7.10.2-3
12	Board memory: ROM and RAM	CO2	T1-3.5
13	Auxiliary memory	CO2	T1-4.2
14	Memory management of external memory, board memory and performance	CO2	T1-4.6
15	Embedded board input / output	CO2	T1-4.7
16	Serial versus parallel I/O	CO2	T1-4.10.6
17	Interfacing the I/O components	CO2	T1-4.11
18	I/O 73 — P a g e Components and performance	CO2	T1-5.1.1
19	Board buses: external communication interfaces	CO2	T1-5.1.1
20	Bus arbitration and timing	CO4	T1-2.11
21	Integrating the bus with other board components, bus performance	CO4	T1-2.3.2
22	Device drivers, device drivers for interrupt-handling	CO2	T1-5.3.3,5.4
23	Memory device drivers	CO4	T1-5.4.2
24	On-board bus device drivers, board I/O drivers	CO2	T1-5.5
25	Explanation about above drivers with suitable examples	CO4	T1-7.1,7.2
26	Embedded operating systems	CO4	T1-7.7.2
27	Multitasking and process management, memory management	CO2	T1-7.3,7.4
28	I/O and file system management	CO2	T1-3.5
29	OS standards example, POSIX OS performance guidelines	CO2	T1-7.8
30	Board support packages	CO2	T1-7.8.1,8.2
31	Middleware and application software	CO4	T1-7.10,11
32	Middle Ware examples	CO4	T1 7.10.3.3
33	Application layer software examples	CO3	T1-5.3

34	Automotive vehicle technology introduction	CO4	T1-7.10.
35	Overview of vehicle categories	CO4	R3-P184
36	Various vehicle sub systems	CO4	R3-P184
37	Like chassis	CO3	R3-P185
38	Body, driveline	CO4	R3-P191
39	Engine technology	CO4	R3-P190
40	Fueling technology	CO4	R3-P190
41	Vehicle emission	CO 4	T1:5.1.1
42	Brakes, suspension	CO5	T1:7.3,7.4
43	Emission, doors	CO5	T1:5.1.1
44	Dashboard instruments	CO5	T1:4.2
45	Wiring harness, safety ,security	CO5	T1:1-7.8
46	comfort and infotainment, communication	CO6	T1:7.4
47	Lighting, future trends in automotive embedded systems	CO6	T1:7.2
48	Automotive sensors and transducers	CO6	T17-7.2
49	Temperature	CO6	T1:5.3.2
50	Manifold and barometric pressures	CO6	T1:4.2
51	Humidity	CO6	T1:5.3
52	Carbon dioxide (CO2), carbon Monoxide (CO)	CO6	R3:P185
53	Carbon Monoxide (CO)	CO6	R3:P186
54	Oxygen (O2) Sensors	CO6	R3-P191
55	Proximity distance sensors	CO6	R3-P1911
56	Engine speed sensors	CO 6	R1:184
57	Throttle position sensors	CO6	T1:4.2
58	Pressure sensors	CO6	T1:4.6
59	Knock sensor	CO6	T1:4.7
60	Mass flow sensor	CO6	T1:5.11
DISCUSSION OF QUESTION BANK			
61	Introduction	CO1	T1:4.6
62	Embedded hardware	CO2	T1:5.11
63	Embedded software	CO4	T1:7.1
64	Automotive systems overview	CO4	T1: 7.10
65	Automotive sensory system	CO6	T1:4.2

Course Coordinator: **HOD, ECE**

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Independently carry out research / investigation and development work to solve practical problems. 1. Independence 2. Self driven. 3. Quality of work. 4.Problem identification and implementation. 5.Demonstrate the solutions 6. Budget.	6
PO 2	Write and present a substantial technical report / document. 1. Demonstrate and communicate effectively in writing report and document/ present orally. 2. Clarity (writing/ presentation) 3. Grammar/ punctuation (writing) 4. References 5. Speaking/ Presenting 6. Subject knowledge while preparing reportProblem or opportunity identification	**6**
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program. 1. Knowledge, understanding and demonstrations of embedded applications in real time scenario. 2.Ability to demonstrate and communicate effectively in writing / orally societal problems. 3. Analyze and design innovative products 4. Problem formulation and abstraction 5.Use creativity to establish innovative solutions 6. Experimental design 7. Manage the design process and evaluate outcomes using modern tools 8.Solution development or experimentation / Implementation 9.Interpretation of results and Validation	**9**

PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications. 1. Understand the need of users with the importance of considerations such as IoT and Robotics 2. Scientific principles and methodology 3. Problem formulation and abstraction 4. Use creativity to establish innovative solutions 5. Experimental design 6. Manage the design process and evaluate outcomes 7. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools 8. Solution development or experimentation / Implementation 9. Interpretation of results and Validation 10. Under take research and development projects in the field of Embedded Systems	**10**
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 1. Maturity – requiring only the achievement of goals to drive their performance 2. Self-direction (take a vaguely defined problem and systematically work to resolution) 3. Individual performance is used during the classroom periods, in the hands-on labs, and in the design projects. 4. Knowledge of management techniques which may be used achieve engineering objectives 5. Meeting deadlines and producing solutions 6. Work with all level of people in the team. 7. Demonstrate ability to work well with a team	**7**
PO 6	Recognize the need to engage in lifelong learning through continuing education and research. 1.Project management and research orientation/ Ph.D 2. Strengthen in embedded and advanced engineering areas 3. Continuing education efforts through literature and courses 4. Personal development 5. Plan tasks and resources, manage risk and produce deliverables 6. Meeting deadlines and producing solutions 7. Work with all levels of people in team 8. Demonstrated ability to work well with a team	**8**