M.Tech – Embedded Systems

Curriculum and Syllabus

2020-21

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics andcritical thinking, for improvement of life.
Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.
Impactful People: Happy, accountable, caring and effective workforce andstudents.
Rewarding Co-creations: Active collaboration with national & internationalindustries & universities for productivity and economic development.
Service to Society: Service to the region and world through knowledge andcompassion.

VISION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

To be a leader by imparting in-depth knowledge in Electronics Engineering, nurturing engineers, technologists and researchers of highest competence, who would engage in sustainable development to cater the global needs of industry and society.

MISSION STATEMENT OF THE SCHOOL OF ELECTRONICS ENGINEERING

- Create and maintain an environment to excel in teaching, learning and applied research in the fields of electronics, communication engineering and allied disciplines which pioneer for sustainable growth.
- Equip our students with necessary knowledge and skills which enable them to be lifelong learners to solve practical problems and to improve the quality of human life.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The graduates of the programme will be able to

PEO 1 Excel in professional career and/or higher education by acquiring solid foundation in science, mathematics and advanced communication engineering and technologies.

PEO 2 Develop and apply engineering solutions for solving contemporary, social and human issues with realistic constraints suitable for the present need through the use of modern tools.

PEO 3 Exhibit professional and ethical standards, effective communication skills, teamwork spirit, multidisciplinary and transdisciplinary approach for successful careers and to be able to compete globally, function as leaders, as entrepreneurs, and manage information efficiently and to engage in lifelong learning.

PROGRAMME OUTCOMES (POs)

On completion of the Programme the students will have the

PO_01: Having an ability to apply mathematics and science in engineering applications.

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints, including public health, safety, culture, society and environment

PO_03: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information

PO_04: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice

PO_05: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems

PO_06: Having adaptive thinking and adaptability in relation to environmental context and sustainable development

PO_07: Having a clear understanding of professional and ethical responsibility

PO_08: Having a good cognitive load management skills related to project management and finance

Programme Specific Outcomes

On completion of M.Tech. Embedded Systems, graduates will be able to

PSO1. Apply the advanced concepts of Embedded System Design with real-time constraints using advanced Microcontrollers and FPGA based systems.

PSO2. Use the cutting-edge technologies in both hardware and software, to solve real-world multi-disciplinary problems and arrive at a viable solution.

PSO3. Independently carry out research on diverse Embedded System strategies to address practical problems and present a substantial technical report.

School of Electronics Engineering (SENSE)

M.Tech - Embedded Systems

CURRICULUM

[Curriculum for Applied Learning (CAL)]

S. No.	Category	Total number of credits
1	University Core (UC)	27
2	University Elective (UE)	06
3	Programme Core (PC)	19
4	Programme Elective (PE)	18
	Total Credits	**70**

DETAILED CURRICULUM

University Core

S. No.	Course Code	Course Title	L	T	P	J	C
1.	MAT6001	Advanced statistical methods	2	0	2	0	3
2.	ENG5001 and ENG5002 or FRE5001/ GER5001	Fundamentals of communication Skills and Professional and communication Skills (or) Foreign Languages	{0 0 2	0 0 0	2 2 0	0 0} 0	2
3.	STS5001 & STS5002	Soft Skills	0	0	0	0	2
4.	SET 5001	SET Project – I	0	0	0	0	2
5.	SET 5002	SET Project – II	0	0	0	0	2
6.	ECE6099	Master's Thesis	0	0	0	0	16

University Elective

S. No.	Course Code	Course Title	L	T	P	J	C
1.		University Elective	0	0	0	0	6

Programme Core

S.No.	Course Code	Course Title	L	T	P	J	C
1.	ECE5041	Embedded System Design	3	0	0	0	3
2.	ECE5042	Microcontroller Architecture and Organization	2	0	2	4	4
3.	ECE5053	Electronic Hardware System Design	2	0	2	4	4
4.	ECE5043	Embedded Programming	3	0	2	0	4
5.	ECE5054	Real Time Operating System	3	0	2	0	4

Programme Elective

S.No.	Course Code	Course Title	L	T	P	J	C
1	ECE6036	In Vehicle Networking	3	0	0	0	3
2	ECE6042	Wireless and Mobile Communication	3	0	0	0	3
3	ECE6043	Advanced Processors and its applications	2	0	0	4	3
4	ECE6044	Electromagnetic Interference and Compatibility in ESD	3	0	0	0	3
5	ECE5045	Advanced Digital Image Processing	3	0	0	0	3
6	ECE6037	Fault Tolerance and Dependable Systems	3	0	0	0	3
7	ECE6046	Advanced Embedded Programming	3	0	0	0	3
8	ECE6047	Design and Analysis of Algorithms	3	0	0	4	4
9	ECE6038	Virtual Instrumentation Systems	0	0	4	4	3
10	ECE6048	Embedded System design using FPGA	2	0	0	4	3
11	ECE5044	Hardware Software Co-design	3	0	0	0	3
12	ECE6049	Modern automotive electronics systems	2	0	0	4	3
13	ECE6073	AUTOSAR and ISO Standards for Automotive Systems	2	0	0	0	2
14	ECE6092	Intelligent IoT System Design and Architecture	2	0	0	4	3
15	ECE6093	Advanced Machine Learning and Deep Learning	3	0	0	0	3
16	ECE6094	Scripting Languages for Design Automation	2	0	2	0	3
17	CSE6052	Parallel Processing and Computing	3	0	0	0	3

University Core

MAT6001	ADVANCED STATISTICAL METHODS	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	**None**	**Syllabus Version**				
		2.0				

Course Objectives

1. To provide students with a framework that will help them choose the appropriate descriptive statistics in various data analysis situations.
2. To analyse distributions and relationships of real-time data.
3. To apply estimation and testing methods to make inference and modelling techniques for decision making using various techniques including multivariate analysis.

Expected Course Outcome

At the end of the course the students are expected to

[1] understand the concept of correlation and regression model and able to interpret the effect of variables, regression coefficients, coefficient of determination.

[2] make appropriate decisions using inferential statistical tools that are central to experimental research.

[3] understand the statistical forecasting methods and model fitting by graphical interpretation of time series data.

[4] construct standard experimental designs and describe what statistical models can be estimated using the data.

[5] demonstrate R programming for statistical data

Module:1	**Basic Statistical Tools for Analysis:**	**4 hours**

Summary Statistics, Correlation and Regression, Concept of R^2 and Adjusted R^2 and Partial and Multiple Correlation, Fitting of simple and Multiple Linear regression, Explanation and Assumptions of Regression Diagnostics

Module:2	**Statistical inference :**	**9 hours**

Basic Concepts, Normal distribution-Area properties, Steps in tests of significance –large sample tests-Z tests for Means and Proportions, Small sample tests –t-test for Means, F test for Equality of Variances, Chi-square test for independence of Attributes.

Module:3	**Modelling and Forecasting Methods:**	**9 hours**

Introduction: Concept of Linear and Non Liner Forecasting model ,Concepts of Trend, Exponential Smoothing, Linear and Compound Growth model, Fitting of Logistic curve and their Applications, Moving Averages, Forecasting accuracy tests.

Probability models for time series: Concepts of AR, ARMA and ARIMA models.

Module:4	**Design of Experiments:**	**6 hours**

Analysis of variance – one and two way classifications – Principle of design of experiments, CRD – RBD – LSD, Concepts of 2^2 and 2^3 factorial experiments.

Module:5	**Contemporary Issues:**	**2 hours**

Industry Expert Lecture

	Total Lecture hours:	**30 hours**
Text Book(s)		
1.	Applied Statistics and Probability for Engineers, Douglas C. Montgomery George C. Runger, 6th edition, John Wiley & Sons (2016),	
2	Time Series Analysis and Its Applications With R Examples, Shumway, Robert H., Stoffer, David S., 4th edition, Springer publications (2017)	
Reference Books		
1.	The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Trevor Hastie and Robert Tibshirani, 2nd Edition, Springer Series, (2017)	
2	Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, J. Susan Milton and Jesse Arnold, McGraw Hill education (2017)	
Mode of Evaluation		
Digital Assignments, Quiz, Continuous Assessments, Final Assessment Test		
List of Challenging Experiments (Indicative)		
1.	Computing Summary Statistics using real time data	3 hours
2	Plotting and visualizing data using Tabulation and Graphical Representations.	3 hours
3	Applying simple linear and multiple linear regression models to real dataset; computing and interpreting the coefficient of determination for scale data.	3 hours
4.	Testing of hypothesis for Large sample tests for real-time problems.	2 hours
5.	Testing of hypothesis for Small sample tests for One and Two Sample mean and paired comparison (Pre-test and Post-test)	2 hours
6.	Testing of hypothesis for Small Sample tests for F-test	2 hours
7	Testing of hypothesis for Small Sample tests for Chi-square test	2 hours
8	Applying Time series analysis-Trends. Growth ,Logistic, Exponential models	2 hours
9	Applying Time series model AR , ARMA and ARIMA and testing Forecasting accuracy tests.	3 hours
10	Performing ANOVA (one-way and two-way), CRD, RBD and LSD for real dataset.	3 hours
11	Performing 2^2 factorial experiments with real time Applications	2 hours
12	Performing 2^3 factorial experiments with real time Applications	3 hours
	Total Laboratory Hours	30 hours

Mode of Evaluation			
Weekly Assessments, Final Assessment Test			
Recommended by Board of Studies	25-02-2017		
Approved by Academic Council	No. 46	Date	24-08-2017

ENG5001	Fundamentals of Communication Skills	L	T	P	J	C
		0	0	2	0	1
Pre-requisite	Not cleared EPT (English Proficiency Test)	**Syllabus version**				
		1.0				

Course Objectives:

1. To enable learners learn basic communication skills - Listening, Speaking, Reading and Writing
2. To help learners apply effective communication in social and academic context
3. To make students comprehend complex English language through listening and reading

Expected Course Outcome:

1. Enhance the listening and comprehension skills of the learners
2.Acquire speaking skills to express their thoughts freely and fluently
3.Learn strategies for effective reading
4.Write grammatically correct sentences in general and academic writing
5. Develop technical writing skills like writing instructions, transcoding etc.,

Module:1	Listening	**8 hours**

Understanding Conversation
Listening to Speeches
Listening for Specific Information

Module:2	Speaking	**4 hours**

Exchanging Information
Describing Activities, Events and Quantity

Module:3	Reading	**6 hours**

Identifying Information
Inferring Meaning
Interpreting text

Module:4	Writing: Sentence	**8hours**

Basic Sentence Structure
Connectives
Transformation of Sentences
Synthesis of Sentences

Module:5	Writing: Discourse	**4hours**

Instructions
Paragraph
Transcoding

	Total Lecture hours:	**30 hours**

Text Book(s)

1. Redston, Chris, Theresa Clementson, and Gillie Cunningham. *Face2face Upper Intermediate Student's Book.* 2013, Cambridge University Press.

Reference Books

1	Chris Juzwiak .*Stepping Stones: A guided approach to writing sentences and Paragraphs (Second Edition)*, 2012, Library of Congress.
2.	Clifford A Whitcomb & Leslie E Whitcomb, *Effective Interpersonal and Team Communication Skills for Engineers*, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.
3.	ArunPatil, Henk Eijkman &Ena Bhattacharya, *New Media Communication Skills for Engineers and IT Professionals*,2012, IGI Global, Hershey PA.
4.	Judi Brownell, *Listening: Attitudes, Principles and Skills*, 2016, 5th Edition, Routledge:USA
5.	John Langan, Ten Steps to Improving College Reading Skills, 2014, 6th Edition, Townsend Press:USA
6.	Redston, Chris, Theresa Clementson, and Gillie Cunningham. *Face2face Upper Intermediate Teacher's Book*. 2013, Cambridge University Press.
	Authors, book title, year of publication, edition number, press, place

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Familiarizing students to adjectives through brainstorming adjectives with all letters of the English alphabet and asking them to add an adjective that starts with the first letter of their name as a prefix.	2 hours
2.	Making students identify their peer who lack Pace, Clarity and Volume during presentation and respond using Symbols.	4 hours
3.	Using Picture as a tool to enhance learners speaking and writing skills	2 hours
4.	Using Music and Songs as tools to enhance pronunciation in the target language / Activities through VIT Community Radio	2 hours
5.	Making students upload their Self- introduction videos in Vimeo.com	4 hours
6.	Brainstorming idiomatic expressions and making them use those in to their writings and day to day conversation	4 hours
7.	Making students Narrate events by adding more descriptive adjectives and add flavor to their language / Activities through VIT Community Radio	4 hours
8	Identifying the root cause of stage fear in learners and providing remedies to make their presentation better	4 hours
9	Identifying common Spelling & Sentence errors in Letter Writing and other day to day conversations	2 hours
10.	Discussing FAQ's in interviews with answers so that the learner gets a better insight in to interviews / Activities through VIT Community Radio	2 hours
	Total Laboratory Hours	**30 hours**

Mode of evaluation: Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 46	Date	24-8-2017

ENG5002	Professional and Communication Skills	L	T	P	J	C
		0	0	2	0	1
Pre-requisite	ENG5001	**Syllabus version**				
		1.1				

Course Objectives:

1. To enable students to develop effective Language and Communication Skills
2. To enhance students' Personal and Professional skills
3. To equip the students to create an active digital footprint

Expected Course Outcome:

1. Improve inter-personal communication skills
2. Develop problem solving and negotiation skills
3. Learn the styles and mechanics of writing research reports
4. Cultivate better public speaking and presentation skills
5. Apply the acquired skills and excel in a professional environment

Module:1	**Personal Interaction**	**2hours**
Introducing Oneself- one's career goals Activity: SWOT Analysis		
Module:2	**Interpersonal Interaction**	**2 hours**
Interpersonal Communication with the team leader and colleagues at the workplace Activity: Role Plays/Mime/Skit		
Module:3	**Social Interaction**	**2 hours**
Use of Social Media, Social Networking, gender challenges Activity: Creating LinkedIn profile, blogs		
Module:4	**Résumé Writing**	**4 hours**
Identifying job requirement and key skills Activity: Prepare an Electronic Résumé		
Module:5	**Interview Skills**	**4 hours**
Placement/Job Interview, Group Discussions Activity: Mock Interview and mock group discussion		
Module:6	**Report Writing**	**4 hours**
Language and Mechanics of Writing Activity: Writing a Report		
Module:7	**Study Skills: Note making**	**2hours**
Summarizing the report Activity: Abstract, Executive Summary, Synopsis		
Module:8	**Interpreting skills**	**2 hours**
Interpret data in tables and graphs Activity: Transcoding		
Module:9	**Presentation Skills**	**4 hours**
Oral Presentation using Digital Tools Activity: Oral presentation on the given topic using appropriate non-verbal cues		
Module:10	**Problem Solving Skills**	**4 hours**
Problem Solving & Conflict Resolution Activity: Case Analysis of a Challenging Scenario		
	Total Lecture hours:	**30hours**

Text Book(s)

1	Bhatnagar Nitin and Mamta Bhatnagar, *Communicative English For Engineers And Professionals*, 2010, Dorling Kindersley (India) Pvt. Ltd.

Reference Books				
1	Jon Kirkman and Christopher Turk, *Effective Writing: Improving Scientific, Technical and Business Communication,* 2015, Routledge			
2	Diana Bairaktarova and Michele Eodice, *Creative Ways of Knowing in Engineering*, 2017, Springer International Publishing			
3	Clifford A Whitcomb & Leslie E Whitcomb, *Effective Interpersonal and Team Communication Skills for Engineers*, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.			
4	ArunPatil, Henk Eijkman &Ena Bhattacharya, *New Media Communication Skills for Engineers and IT Professionals*,2012, IGI Global, Hershey PA.			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
List of Challenging Experiments (Indicative)				
1.	SWOT Analysis – Focus specially on describing two strengths and two weaknesses			2 hours
2.	Role Plays/Mime/Skit -- Workplace Situations			4 hours
3.	Use of Social Media – Create a LinkedIn Profile and also write a page or two on areas of interest			2 hours
4.	Prepare an Electronic Résumé and upload the same in vimeo			2 hours
5.	Group discussion on latest topics			4 hours
6	Report Writing – Real-time reports			2 hours
7	Writing an Abstract, Executive Summary on short scientific or research articles			4 hours
8	Transcoding – Interpret the given graph, chart or diagram			2 hours
9	Oral presentation on the given topic using appropriate non-verbal cues			4 hours
10	Problem Solving -- Case Analysis of a Challenging Scenario			4 hours
			Total Laboratory Hours	**30 hours**
Mode of evaluation: : Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project				
Recommended by Board of Studies	22-07-2017			
Approved by Academic Council	No. 47	Date	05-10-2017	

FRE5001	FRANCAIS FONCTIONNEL	L	T	P	J	C
		2	0	0	0	2

Pre-requisite	Syllabus version
Nil	1.0

Course Objectives:

The course gives students the necessary background to:

1. Demonstrate competence in reading, writing, and speaking basic French, including knowledge of vocabulary (related to profession, emotions, food, workplace, sports/hobbies, classroom and family).
2. Achieve proficiency in French culture oriented view point.

Expected Course Outcome:

The students will be able to

1. Remember the daily life communicative situations via personal pronouns, emphatic pronouns, salutations, negations, interrogations etc.
2. Create communicative skill effectively in French language via regular / irregular verbs.
3. Demonstrate comprehension of the spoken / written language in translating simple sentences.
4. Understand and demonstrate the comprehension of some particular new range of unseen written materials.
5. Demonstrate a clear understanding of the French culture through the language studied.

Module:1	Saluer, Se présenter, Etablir des contacts	**3 hours**

Les Salutations, Les nombres (1-100), Les jours de la semaine, Les mois de l'année, Les Pronoms Sujets, Les Pronoms Toniques, La conjugaison des verbes réguliers, La conjugaison des verbes irréguliers- avoir / être / aller / venir / faire etc.

Module:2	**Présenter quelqu'un, Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.**	**3 hours**

La conjugaison des verbes Pronominaux, La Négation, L'interrogation avec *'Est-ce que ou sans Est-ce que'*.

Module:3	**Situer un objet ou un lieu, Poser des questions**	**4 hours**

L'article (défini/ indéfini), Les prépositions (à/en/au/aux/sur/dans/avec etc.), L'article contracté, Les heures en français, La Nationalité du Pays, L'adjectif (La Couleur, l'adjectif possessif, l'adjectif démonstratif/ l'adjectif interrogatif (quel/quelles/quelle/quelles), L'accord des adjectifs avec le nom, L'interrogation avec Comment/ Combien / Où etc.,

Module:4	**Faire des achats, Comprendre un texte court, Demander et indiquer le chemin.**	**6 hours**

La traduction simple :(français-anglais / anglais –français)

Module:5	**Trouver les questions, Répondre aux questions générales en français.**	**5 hours**

L'article Partitif, Mettez les phrases aux pluriels, Faites une phrase avec les mots donnés, Exprimez les phrases données au Masculin ou Féminin, Associez les phrases.			
Module:6	**Comment ecrire un passage**		**3 hours**
Décrivez : La Famille /La Maison, /L'université /Les Loisirs/ La Vie quotidienne etc.			
Module:7	**Comment ecrire un dialogue**		**4 hours**
Dialogue: a) Réserver un billet de train b) Entre deux amis qui se rencontrent au café c) Parmi les membres de la famille d) Entre le client et le médecin			
Module:8	**Invited Talk: Native speakers**		**2 hours**
	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	Echo-1, Méthode de français, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
2	Echo-1, Cahier d'exercices, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
Reference Books	
1.	CONNEXIONS 1, Méthode de français, Régine Mérieux, Yves Loiseau,Les Éditions Didier, 2004.
2	CONNEXIONS 1, Le cahier d'exercices, Régine Mérieux, Yves Loiseau, Les Éditions Didier, 2004.
3	ALTER EGO 1, Méthode de français, Annie Berthet, Catherine Hugo, Véronique M. Kizirian, Béatrix Sampsonis, Monique Waendendries , Hachette livre 2006.

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies			
Approved by Academic Council	No 41	Date	17-06-2016

GER5001	Deutsch für Anfänger	L	T	P	J	C
		2	0	0	0	2
Pre-requisite	**NIL**	**Syllabus version**				
		1.0				

Course Objectives:

The course gives students the necessary background to:

1. Enable students to read and communicate in German in their day to day life
2. Become industry-ready
3. Make them understand the usage of grammar in the German Language.

Expected Course Outcome:

The students will be able to

1. Create the basics of German language in their day to day life.
2. Understand the conjugation of different forms of regular/irregular verbs.
3. Understand the rule to identify the gender of the Nouns and apply articles appropriately.
4. Apply the German language skill in writing corresponding letters, E-Mails etc.
5. Create the talent of translating passages from English-German and vice versa and To frame simple dialogues based on given situations.

Module:1 **3 hours**

Einleitung, Begrüssungsformen, Landeskunde, Alphabet, Personalpronomen, Verb Konjugation, Zahlen (1-100), W-fragen, Aussagesätze, Nomen – Singular und Plural

Lernziel:

Elementares Verständnis von Deutsch, Genus- Artikelwörter

Module:2 **3 hours**

Konjugation der Verben (regelmässig /unregelmässig) die Monate, die Wochentage, Hobbys, Berufe, Jahreszeiten, Artikel, Zahlen (Hundert bis eine Million), Ja-/Nein- Frage, Imperativ mit Sie

Lernziel :

Sätze schreiben, über Hobbys erzählen, über Berufe sprechen usw.

Module:3 **4 hours**

Possessivpronomen, Negation, Kasus- AkkusatitvundDativ (bestimmter, unbestimmterArtikel), trennnbare verben, Modalverben, Adjektive, Uhrzeit, Präpositionen, Mahlzeiten, Lebensmittel, Getränke

Lernziel :

Sätze mit Modalverben, Verwendung von Artikel, über Länder und Sprachen sprechen, über eine Wohnung beschreiben.

Module:4 **6 hours**

Übersetzungen : (Deutsch – Englisch / Englisch – Deutsch)

Lernziel :

Grammatik – Wortschatz – Übung

Module:5 **5 hours**

Leseverständnis,Mindmap machen,Korrespondenz- Briefe, Postkarten, E-Mail

Lernziel :

Wortschatzbildung und aktiver Sprach gebrauch		
Module:6	.	**3 hours**
Aufsätze : Meine Universität, Das Essen, mein Freund oder meine Freundin, meine Familie, ein Fest in Deutschland usw		
Module:7		**4 hours**
Dialoge: e) Gespräche mit Familienmitgliedern, Am Bahnhof, f) Gespräche beim Einkaufen ; in einem Supermarkt ; in einer Buchhandlung ; g) in einem Hotel - an der Rezeption ;ein Termin beim Arzt. Treffen im Cafe		
Module:8		**2 hours**
Guest Lectures/Native Speakers / Feinheiten der deutschen Sprache, Basisinformation über die deutschsprachigen Länder		

	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	**Studio d A1 Deutsch als Fremdsprache, Hermann Funk, Christina Kuhn, Silke Demme : 2012**
Reference Books	
1	Netzwerk Deutsch als Fremdsprache A1, Stefanie Dengler, Paul Rusch, Helen Schmtiz, Tanja Sieber, 2013
2	Lagune ,Hartmut Aufderstrasse, Jutta Müller, Thomas Storz, 2012.
3	Deutsche SprachlehrefürAUsländer, Heinz Griesbach, Dora Schulz, 2011
4	ThemenAktuell 1, HartmurtAufderstrasse, Heiko Bock, MechthildGerdes, Jutta Müller und Helmut Müller, 2010
	www.goethe.de wirtschaftsdeutsch.de hueber.de, klett-sprachen.de www.deutschtraning.org

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies			
Approved by Academic Council	No. 41	Date	17-06-2016

STS5001	Essentials of Business Etiquettes	L	T	P	J	C
		3	0	0	0	1
Pre-requisite		**Syllabus version**				
		2.0				

Course Objectives:

1. To develop the students' logical thinking skills
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To enhance critical thinking and innovative skills

Expected Course Outcome:

- Enabling students to use relevant aptitude and appropriate language to express themselves
- To communicate the message to the target audience clearly

Module:1	**Business Etiquette: Social and Cultural Etiquette and Writing Company Blogs and Internal Communications and Planning and Writing press release and meeting notes**	**9 hours**

Value, Manners, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body – Make it relevant to your audience,

Module:2	**Study skills – Time management skills**	**3 hours**

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines

Module:3	**Presentation skills – Preparing presentation and Organizing materials and Maintaining and preparing visual aids and Dealing with questions**	**7 hours**

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

Module:4	**Quantitative Ability -L1 – Number properties and Averages and Progressions and Percentages and Ratios**	**11 hours**

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions

Module:5	**Reasoning Ability-L1 – Analytical Reasoning**	**8 hours**
Data Arrangement(Linear and circular & Cross Variable Relationship), Blood Relations, Ordering/ranking/grouping, Puzzle test, Selection Decision table		
Module:6	**Verbal Ability-L1 – Vocabulary Building**	**7 hours**
Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies		
	Total Lecture hours:	**45 hours**

Reference Books	
1.	Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler(2001) Crucial Conversations: Tools for Talking When Stakes are High. Bangalore. McGraw-Hill Contemporary
2.	Dale Carnegie,(1936) How to Win Friends and Influence People. New York. Gallery Books
3.	Scott Peck. M(1978) Road Less Travelled. New York City. M. Scott Peck.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.
Websites:	
1.	www.chalkstreet.com
2.	www.skillsyouneed.com
3.	www.mindtools.com
4.	www.thebalance.com
5.	**www.eguru.ooo**

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays,
3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies	09/06/2017		
Approved by Academic Council	No. 45th AC	Date	15/06/2017

STS5002	Preparing for Industry	L	T	P	J	C
		3	0	0	0	1

Pre-requisite	Syllabus version
	2.0

Course Objectives:

5. To develop the students' logical thinking skills
6. To learn the strategies of solving quantitative ability problems
7. To enrich the verbal ability of the students
8. To enhance critical thinking and innovative skills

Expected Course Outcome:

- Enabling students to simplify, evaluate, analyze and use functions and expressions to simulate real situations to be industry ready.

Module:1	Interview skills – Types of interview and Techniques to face remote interviews and Mock Interview	3 hours

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview¸ Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds

Module:2	Resume skills – Resume Template and Use of power verbs and Types of resume and Customizing resume	2 hours

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout - Understanding different company's requirement, Digitizing career portfolio

Module:3	Emotional Intelligence - L1 – Transactional Analysis and Brain storming and Psychometric Analysis and Rebus Puzzles/Problem Solving	12 hours

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure, Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways

Module:4	Quantitative Ability-L3 – Permutation-Combinations and Probability and Geometry and mensuration and Trigonometry and Logarithms and Functions and Quadratic Equations and Set Theory	14 hours

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram		
Module:5	**Reasoning ability-L3 – Logical reasoning and Data Analysis and Interpretation**	**7 hours**
Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar chats		
Module:6	**Verbal Ability-L3 – Comprehension and Logic**	**7 hours**
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument		
	Total Lecture hours:	**45 hours**

Reference Books	
1.	Michael Farra and JIST Editors(2011) Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Saint Paul, Minnesota. Jist Works
2.	Daniel Flage Ph.D(2003) The Art of Questioning: An Introduction to Critical Thinking. London. Pearson
3.	David Allen(2002) Getting Things done : The Art of Stress -Free productivity. New York City. Penguin Books.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia.Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.
Websites:	
1.	www.chalkstreet.com
2.	www.skillsyouneed.com
3.	www.mindtools.com
4.	www.thebalance.com
5.	www.eguru.ooo

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)			
Recommended by Board of Studies	09/06/2017		
Approved by Academic Council	No. 45th AC	Date	15/06/2017

Programme Core

Course Code	Course Title	L	T	P	J	C
ECE5041	EMBEDDED SYSTEM DESIGN	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version ~~1.1~~				

Course Objectives:

The course aimed at

1. Ability to understand comprehensively the technologies and techniques underlying in building an embedded solution to a wearable, mobile and portable system.
2. Analyze UML diagrams and advanced Modelling schemes for different use cases.
3. Understand the building process of embedded systems

Expected Course Outcome:

The students will be able to

1. Define an embedded system and compare with general purpose system.
2. Appreciate the methods adapted for the development of a typical embedded system.
3. Get introduced to RTOS and related mechanisms.
4. Classify types of processors and memory architecture
5. Differentiate the features of components and networks in embedded systems
6. Develop real-time working prototypes of different small-scale and medium-scale embedded Systems.
7. Apprehend the various concepts in Multi Tasking

Module:1	Introduction to Embedded System	5 hours

Embedded system processor, hardware unit, software embedded into a system, Example of an embedded system, Embedded Design life cycle, Layers of Embedded Systems.

Module:2	Embedded System Design Methodologies	5 hours

Embedded System modelling [FSM, SysML, MARTE], UML as Design tool, UML notation, Requirement Analysis and Use case Modelling, Design Examples

Module:3	Building Process For Embedded Systems	4 hours

Preprocessing, Compiling, Cross Compiling, Linking, Locating, Compiler Driver, Linker Map Files, Linker Scripts and scatter loading, Loading on the target, Embedded File System.

Module:4	System design using general purpose processor	7 hours

Microcontroller architectures (RISC, CISC), Embedded Memory, Strategic selection of processor and memory, Memory Devices and their Characteristics, Cache Memory and Various mapping techniques, DMA.

Module:5	Component Interfacing & Networks	9 hours

Memory Interfacing, I/O Device Interfacing, Interrupt Controllers, Networks for Embedded systems- USB, PCI,PCI Express, UART, SPI, I2C, CAN, Wireless Applications - Bluetooth, Zigbee,Wi-Fi.,6LoWPAN , Evolution of Internet of things (IoT).

Module:6	Operating Systems	7 hours

Introduction to Operating Systems, Basic Features & Functions of an Operating System, Kernel & its Features [polled loop system, interrupt driven system, multi rate system], Processes/Task and its states, Process/Task Control Block, Threads, Scheduler, Dispatcher.			
Module:7	**Multi Tasking**		**6 hours**
Context Switching , Scheduling and various Scheduling algorithms, Inter-process Communication (Shared Memory, Mail Box, Message Queue), Inter Task Synchronization (Semaphore, Mutex), Dead Lock, Priority Inversion (bounded and unbounded), Priority Ceiling Protocol & Priority Inheritance Protocol			
Module:8	**Contemporary issues:**	**2 hours**	
	Total Lecture hours:	**45 hours**	

Text Book(s)	
1.	Raj Kamal, “Embedded systems Architecture, Programming and Design”, Tata McGraw- Hill, 2016.
2.	Wayne Wolf “Computers as components: Principles of Embedded Computing System Design”, The Morgan Kaufmann Series in Computer Architecture and Design, 2013.
Reference Books	
1.	Lyla B. Das," Embedded Systems an Integrated Approach", Pearson Education, 2013.
2.	Shibu K V," Introduction to Embedded Systems", McGraw Hill Education(India) Private Limited, 2014
3.	Sriram V Iyer, Pankaj Gupta " Embedded Real Time Systems Programming", Tata McGraw- Hill, 2012
4.	Steve Heath, “Embedded Systems Design”, EDN Series, 2013.
Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.	

Recommended by Board of Studies		12/09/2020	
Approved by Academic Council	No. 59	Date	24/09/2020

Course code	Course Title	L	T	P	J	C
ECE5042	Microcontroller Architecture and Organization	2	0	2	4	4
Pre-requisite	Nil	Syllabus version: 1				

Course Objectives:

The course is aimed at
[1] Describing the architecture of 8051 microcontroller and ARM processor
[2] Teaching the instruction set of 8051 and ARM microcontroller to efficient programs
[3] Designing system in block level using microcontroller, memory devices, buses and other peripheral devices
[4] Solving real life problem using microcontroller-based systems

Expected Course Outcome:

At the end of the course, the students will be able to
[1] Describe the architectures of processors
[2] Develop Assembly program applying Digital logic and mathematics using 8051
[3] Develop Assembly Language Program ALP for ARM and ARM peripherals
[4] Develop ALP with minimum instructions and memory.
[5] Analyze and evaluate the given program in terms of code size and computational time
[6] Design Microcontroller based system within realistic constraint like user specification, availability of components etc
[7] Solve real life problem and construct a complete system as a solution
[8] Integrate and build a working model using the laboratory components and IDE tools.

Module:1	**Introduction to Microcontrollers**	**2 hours**	
Microprocessors Vs Microcontrollers; Classification – bits, memory architecture, ISA; Little Endian Vs Big Endian.			
Module:2	**8051 Microcontroller**	**2 hours**	
Architecture – Timers, Interrupts, Register Architecture (banks), PSW register, Memory architecture; Instruction set.			
Module:3	**8051 Programming and Interfaces**	**5 hours**	
Programming in C & Assembly for – Interrupts, Timers and Interfaces – PORTS, LED, ADC, SENSORS, LCD, DAC, Serial Communication.			
Module:4	**ARM Architecture**	**3 hours**	
ARM Design Philosophy; Overview of ARM architecture; States [ARM, Thumb, Jazelle]; Registers, Modes; Conditional Execution; Pipelining; Vector Tables; Exception handling.			
Module:5	**ARM Instruction Set**	**6 hours**	
ARM Instruction- data processing instructions, branch instructions, load store instructions, SWI instruction, Loading instructions, conditional Execution, Assembly Programming.			
Module:6	**Thumb Instruction Set**	**4 hours**	
Thumb Instruction-Thumb Registers, ARM Thumb interworking, branch instruction, data processing instruction, single/multiple load store instruction, Stack instruction, SWI instruction, Assembly Programming.			
Module:7	**ARM Core based Microcontroller**	**6 hours**	
Architecture of LPC214X, Memory Addressing, IO ports, Timers/counter, Watch Dog Timer, PWM, ADC/DAC, UART, Interrupts, Displays, C programming.			
Module:8	**Contemporary Issues**	**2 hours**	
	Total Lecture Hours:	**30 hours**	

Text Book(s)

1. Andrew N.Sloss, Dominic Symes, Chris Wright, ARM Developer's Guide, 2010, 1st Edition, Elsevier, United States
2. Kenneth Ayala, The 8051 Microcontroller & Embedded Systems Using Assembly and C, 2010, 1st edition, Cengage Learning, United States

Reference Books

1.Steve Furber ARM System on Chip Architecture, 2010, 2nd Edition, Addison Wesley, United States
2. Technical Reference Manual CORTEX M-3, ARM, 2010, United States

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	**Task-1: Calculator Application** Sub task 1: Make the LCD interfaced to 8051 Sub task 2: Get input from switch which is interfaced to 8051 and display it on LCD Sub task 3: Based on switch input, perform basic operation of a Calculator	7 hours
2.	**Task-2: Speed control of motor** Sub task-1: Use timer and generate an exact time delay for T_{ON} and T_{OFF} Sub task-2: Use timer interrupt in generating the waveform Sub tast-3: Controlling speed of a DC motor using Timer	7 hours
3.	**Task-3: Microcontroller based application** Sub task-1: Interface Zigbee with 8051 Sub Task-2: Interface keypad with 8051 Sub Task-3: Interface GSM with 8051 Sub task-4: Based on KEY pressed in keypad, transmit the key info via Zigbee and make a motor to rotate, which is interfaced with 8051. Using GSM module send the status of motor[run/stop] to the user.	8 hours
4.	**Task-4: Sensor interfacing with ARM LPC2148** Sub Task-1: Interface IR with LPC2148 Sub Task-2: Interface temperature sensor with LPC2148 Sub Task-3: Interface Bluetooth with LPC2148 Sub Task-4: Transmit the IR detail and sensor data to another LPC2148 via Bluetooth.	8 hours
	Total Laboratory Hours	30 hours

Typical Projects

1. Develop an ARM based waste management system. In this, the sensors are placed in the common garbage bins placed at the public places. When the garbage reaches the level of the sensor, then that indication will be given to ARM Micro controller. The controller will give indication to the driver of garbage collection truck as to which garbage bin is completely filled and needs urgent attention. ARM 7 will give indication by sending SMS using GSM technology.

2. Design an ARM based automated patient monitoring system which continuously measures the patient parameters such as heart rate and rhythm, respiratory rate, blood pressure and many other parameters has become a common feature of the care of critically ill patients. When accurate and immediate decision-making is crucial for effective patient care, electronic monitors frequently are used to collect and display physiological data.

3. Implement a Digital Clock and Alarm using ARM microcontroller that needs a keypad to be interfaced with the following requirement. Key 1 to turn on alarm, Key 2 to enable alarm settings, Key 3 to enable time settings, Key 4 to change hour's settings, Key 5 to change minute settings, Key 6 to increment the time, Key 7 to decrement the time. The normal time and alarm time should be displayed using 2 X 16 LCD and a buzzer should be triggered once the normal time equal to alarm time.

4. Develop an ARM Micro controller-based precision agriculture which includes accessing real-time data about the conditions of the crops, soil and ambient air. Sensors in fields measure the moisture content and temperature of the soil and surrounding air.

Recommended by Board of Studies	27/02/2016		
Approved by Academic Council	No. 40th	Date	18-03-2016

Course Code	Course Title	L	T	P	J	C
ECE5053	ELECTRONICS HARDWARE SYSTEM DESIGN	2	0	2	4	4
Pre-requisite	Nil					

Course Objectives:

The course is aimed at

[1] Emphasing students the significant role of FPGA in System design and development.

[2] Teaching the students to develop program using Hardware Descriptive Language and model digital logic combinational and sequential circuits.

[3] Enabling the students acquire knowledge in Interfacing peripherals, Board Design, Packaging, PCB Design and Analysis

[4] Motivating students to solve real life problem using FPGA based systems.

Course Outcomes (CO):

At the end of the course the student will be able to

[1] Comprehend the architecture of FPGA and design flow

[2] Understand Hardware Description Language

[3] Design and develop combinational logic circuits using Verilog and VHDL program.

[4] Design and develop sequential logic circuits using Verilog and VHDL program.

[5] Interface peripherals with FPGA.

[6] Design the PCB

[7] Design FPGA based system

[8] Comprehend upcoming trends in FPGA.

Module:1	Programmable Logic Devices & FPGAs	3 hours	

Introduction to FPGAs, FPGA technologies, FPGA Architectures [Xilinx, Altera, ACTEL, LATTICE], FPGA Design Flow Prototyping with Xilinx FPGAs, FPGA based Testing.

Module:2	Hardware Descriptive Language (Verilog/VHDL)	3 hours	

Introduction, HDL Design flow, Language constructs -operators –Data types, Different architectures (Structural, Behavioural, Dataflow)-Design examples

Module:3	Modeling of Combinational logic circuits	4 hours	

Half adder, Full adder, 4-bit/8-bit binary adder, ALU design, Multiplexer and De-multiplexer, Encoder, Decoder, Comparator, Ripple Carry Adder, Carry Look ahead adder.

Module:4	Modeling of Sequential logic circuits	4 hours	

Flip Flops-Realization of Shift Register -Realization of a Counter-Synchronous and Asynchronous – BCD counter, Mealy and Moore State Machines, Sequence detector, FIFO, Memory Design, Serial Data Receiver, Serial to parallel data converter.

Module:5	Interfacing peripherals and Board Design	5 hours	

Interfacing to 7 segment display, Stepper Motor, ADC and Sensors, FPGA System Architecture, Constraints –Logical –Electrical -Physical, Power distribution for FPGAs, Clock design, I/O buses.

Module:6	Introduction to Packaging &PCB Design	4 hours	

Physical integration of circuits, packages, boards and full electronic systems - Package classifications (Through hole and SMDs) and packaging trends, Hierarchy of Interconnection Levels -Signal integrity - The PCB Design Process - Defining the Layout Cross Section - Design Rules Checking - Working with Properties & Constraints- PCB Electrical Design Consideration - Design tips for Placement / Fan-out and Wiring - Multi - Layer Design Issues.

Module:7	High Speed PCB design and Analysis	5 hours	

High speed PCB design -EMI/EMC analysis - Thermal management of electronic devices and systems -Thermal interface material, Cooling mechanisms-System level design of electronic hardware for automotive applications -System level testing and validation of automotive electronics systems for reliability. Layout constraints for FPGAs, FPGA-based PCB schematics.			
Module:8	**Contemporary issues:**	**2 hours**	
			Total Lecture hours: 30 hrs
Text Book(s) 1. Simon Monk, Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards, 2014, First Edition, McGraw Hill Education, India. 2. Wayne Wolf, FPGA-based System Design, 2011, Re-Print, Prentice Hall, India			
Reference Books 1. Clyde Coombs, Printed Circuits Handbook, 2011, Sixth Edition, McGraw Hill Professional, USA 2. Ian Grout, Digital Systems, Design with FPGAs and CPLDs, 2012, Re-Print, Newness, UK. 3. Ronald R. Sass and Andrew Schmidt, Embedded Systems Design with Platform FPGAs: Principles and Practices, 2010, First Edition, Morgan Kaufman Publishers, USA.			
Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.			
List of Challenging Experiments (Indicative)			
1.	Task 1: Combination Logic:- Design a 16-bit microprocessor that is capable of performing both logical and arithmetic operation.		8 hours
2.	Task 2: Sequential Logic:- Design a controller for vending machine which sells candy bars for Rs 5, 10 and 20.		8 hours
3.	Task 3: Peripheral Interfacing:- Design a car speed monitor using the following components (a) 7 segment display (b) LEDs (c) Switches for speed selection and (d) Buzzer. The cars electronic speedometer provides a clock signal whose frequency is proportional to the speed. To check the functioning of the design use function generator to provide the speedometer clock.		8 hours
4.	Task 4:PCB Design:- Design a PCB for a circuit with a mixture of analog and digital parts, multiple power planes, and a single Ground plane split into analog and digital sections that have a common reference point using open source tool.		6 hours
			Total Laboratory Hours : 30 Hours
Mode of Evaluation: Continuous Assessment Test, Final Assessment Test			
Typical Projects:			

1. Design face recognition based Authenticated Door Opening System using FPGA. Database consisting of authorised persons faces should be created and the same should be compared with the real time camera input faces such that, if face matching happens then the door actuator needs to be triggered to open the door.
2. FPGA Implementation of Digital Clock and Alarm needs a keypad to be interfaced with the following requirement. Key 1 to turn on alarm, Key 2 to enable alarm settings, Key 3 to enable time settings, Key 4 to change hour's settings, Key 5 to change minute settings, Key 6 to increment the time and Key 7 to decrement the time. The normal time and alarm time should be displayed using 2 X 16 LCD and a buzzer should be triggered once the normal time equal to alarm time.
3. Design a GCD (Greatest Common divider) processor in FPGA. Use finite state machine approach of modelling the processor and generate the structure of Controller and Data path. The input should be given through the keypad which is to be interfaced with FPGA and the results should be serially transmitted to the Personal Computer through UART (Universal Asynchronous Receiver Transmitter) communication protocol.
4. Design a PCB of 3.3V/5V Power Supply and GSM Module. Individual switches need to be included to ON/OFF the individual Power Supply. The power supply and GSM schematic, top layer, bottom layer, top silk, top mask, top preview, bottom preview, bottom mask, drill file should be generated and captured during the design phase.

Mode of Evaluation: Project Reviews I, II, III

Approved by Academic Council : No. 40

Course code	Course Title	L	T	P	J	C
ECE5043	EMBEDDED PROGRAMMING	3	0	2	0	4
Pre-requisite	None	Syllabus version				

Course Objectives :

The course is aimed

1. To acquaint students with fundamentals of C
2. To familiarize the students with data structures
3. To introduce the students with SHELL programming and Linux
4. To Implement the Device drivers in LINUX environment

Expected Course Outcome :

At the end of the course the students will be able to

1. Comprehend the fundamentals of C
2. Comprehend the Data structures
3. Comprehend the basics of Linux
4. Showcase the skill, knowledge and ability of SHELL programming.
5. Exhibit the working knowledge of basic Embedded Linux
6. Comprehend the concepts of Kernel module Programming
7. Write Device driver programs
8. Have hands on experience in using state-of- art hardware and software tools

Module:1	C Language	7 hours

Basic concepts of C, Embedded C Vs C, Embedded programming aspects with respect to firmware and OS Functions, Arrays, pointers, structures and Inputs/Outputs.

Module:2	Data structures of kernel programming	6 hours

Linked list, Single linked list, Double linked list and Queues.

Module:3	Linux	6 hours

Command prompt, X windows basics, Navigating file system, finding files, working with folders, reading files text editing in Linux, Compression and archiving tools, Basic shell commands, File Management, I/O Handling, File Locking.

Module:4	Shell Programming	7 hours

Processes, giving more than one command at a time, prioritizing and killing processes, Scheduling Commands, pipes and redirection, regular expression, pattern matching, Scripting using for while, if and other commands.

Module:5	Embedded Linux	6 hours

Linux Basics, Booting process, make files , using SD card and reader to transfer programs, Introduction to LINUX system calls, API's, device drivers, compiling and installing a device driver.

Module:6	Kernel Module Programming	6 hours

Compiling kernel, Configuring Kernel and compilation, Kernel code, browsers.-Static linking, dynamic linking of modules, User space, kernel space concepts, Writing simple modules – Writing, Make-files for modules.

Module:7	**Device Driver concepts**	**5 hours**
Driver concepts, Block & character driver distinction, Low level drivers, OS drivers etc, Writing character drivers, Device major, minor number.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1.	Neil Mathew, Richard stones, Beginning Linux Programming, 2012 reprint, Wrox – Wiley Publishing, USA.
2.	Eric Foster Johnson, John C. Welch, Micah Anderson, Beginning shell scripting, 2012, reprint, Wrox – Wiley Publishing, USA

Reference Books

3.	Derek Molloy, Exploring Beagle Bone: Tools and Techniques for Building with Embedded Linux, 2015, 1st Edition, Wiley Publications, USA

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Task1: C programming • Implement a binary tree sorting • Implement a dice throw game • Implement a command line argument based application of automation	6 hours
2.	Task2: Implementation of data structure for an application Write a SortedMerge() function that takes two lists, each of which is sorted in increasing order, and merges the two together into one list which is in increasing order. SortedMerge() should return the new list. The new list should be made by splicing together the nodes of the first two lists.	6 hours
3.	Task3: Shell Programming Development of inventory management system using Shell scripting with the following features • User may add/update/delete inventory. • User may add/update inventory details. • Details include cost, quantity and description. • Includes forms for inventory inwards and outwards. • User may create sub-inventories. • An interactive user interface. • A flexible inventory management system.	6 hours
4	Task4: Build process for an embedded board Build a kernel for a Beagle Bone Black (BBB) board and board bring up, kernel module program on an embedded board	6 hours
5.	Task5: Device driver programming –Implementation of Device Driver	6 hours
Total Laboratory Hours		30 hours

Mode of evaluation: Continuous Lab Assessment			
Recommended by Board of Studies	12/09/2020		
Approved by Academic Council	No. 59th	Date	24/09/2020

Course Code	Course Title	L	T	P	J	C
ECE5054	REAL TIME OPERATING SYSTEMS	3	0	2	0	4
Pre-requisite	Nil	Syllabus Version :1.1				

Course Objectives:

The course is aimed at

[1]Introducing the students about Operating Systems and acquainting students to Real Time Operating Systems

[2]Teaching the students about Task Management and Enabling students to understand RTOS Scheduling

[3]Introducing the students about interprocess communication and Memory Management

Course Outcomes (CO):

At the end of the course the will should be able to

[1]Comprehend the basic components of an operating system

[2] Learn about the basics of real-time concepts

[3]Acquire knowledge about task management

[4]Acquaint with RTOS scheduling

[5]Learn about IPC synchronization

[6]Learn about IPC data exchange

[7]Perform memory management in RTOS

[8]Apply the knowledge for developing practical applications of modern real-time systems.

Module:1	**Introduction to Operating Systems**	**6 hours**	
Layers of Operating Systems, Operating systems functions, System Boot up - BIOS & Boot Process, Kernel – Monolithic and Microkernel			
Module:2	**Real Time Operating Systems**	**7 hours**	
Tradeoffs for RTOS, POSIX			
Module:3	**Task Management**	**7 hours**	
Process and Threads, Process Control Block, Process Attributes, POSIX Threads.			
Module:4	**RTOS Scheduling**	**7 hours**	
Priority based scheduling, Rate-Monotonic scheduling, Earliest Deadline first scheduling, Linux RT scheduler.			
Module:5	**IPC - Synchronization**	**7 hours**	
IPC, Race conditions and critical sections, Signals, Atomic operations, Semaphore, Mutex, Spinlock, Priority Inversion and Priority ceiling.			
Module:6	**IPC – Data Exchange**	**7 hours**	
Shared memory, FIFO, Messages and Mailbox, Circular and swinging buffers, RPC			
Module:7	**Memory Management**	**2 hours**	
Memory Management, shared memory			
Module:8	**Contemporary issues:**	**2 hours**	
			Total Lecture hours: 45 hrs

Text Book(s)

1. Herma K., Real Time Systems, Design for distributed Embedded Applications, 2011, 2nd edition, Springer, USA.
2. Tanenbaum, Andrew, Modern Operating Systems, 2015, 4th ed.,, Pearson Prentice Hall, USA

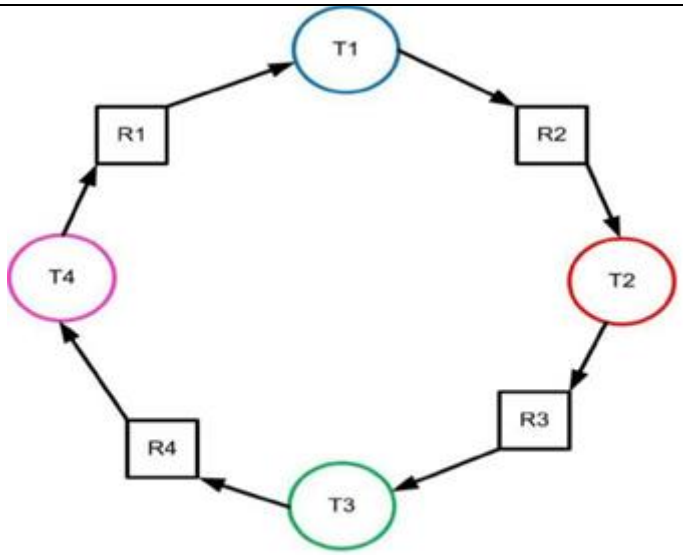
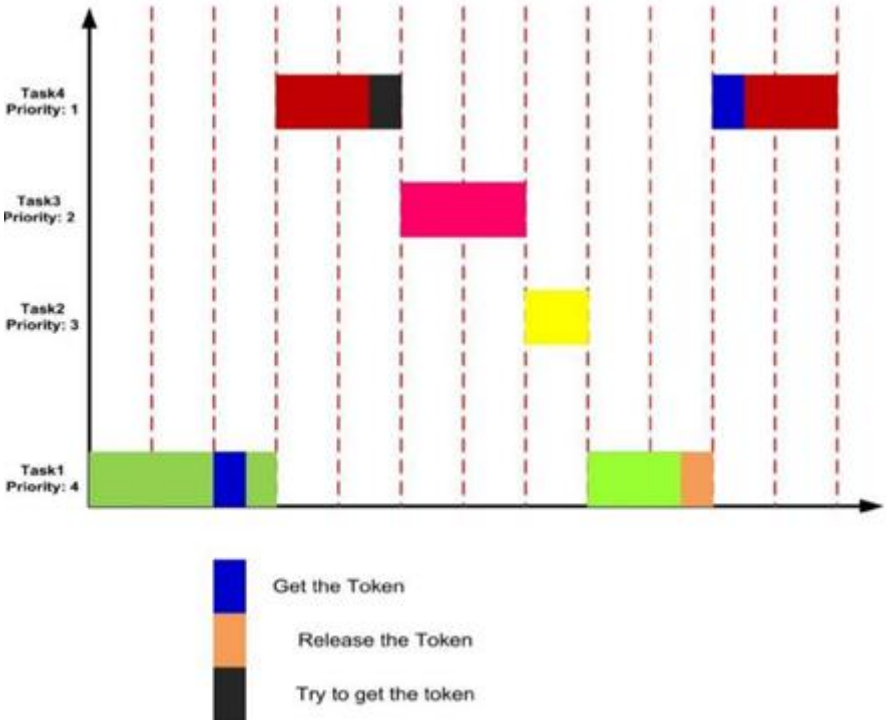
Reference Books

1. Ivan CibrarioBertolotti, Politecnico di Torino and Gabriele Manduchi, Real-Time Embedded Systems: Open-Source Operating Systems Perspective, 2012, 1st ed., CRC Press, USA.
2. Lyla B. Das, Embedded Systems an Integrated Approach, 2012, 1st ed., Pearson Education, India.

Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Challenging Experiments, Final Assessment Test.

List of Challenging Experiments (Indicative)

1.	Write a C code for a simple calculator (+, -, *, /) using functional pointer as argument in a function int add (int x, int y) int sub (int x, int y) int mul (int x, int y) int div (int x, int y) int (*mathop)(int, int) int domath(int (*mathop)(int , int), int x, int y)	6 hours
2.	Write a program to create multiple threads carrying out different functions. Thread 1: Accepting a string from the user. Thread 2: Display the string in upper case. Thread 3: Count the number of vowels in the string Thread 4: Count the number of special characters in the string.	6 hours
3.	Write a program to create three threads, which are implemented using function pointers. First thread is for getting a list of numbers from the keyboard, second thread is helpful to extract the ODD and EVEN list from the given list, and the third one is used to arrange the ODD and EVEN list of numbers in an order. Use Mutex semaphore. Note: First Thread for getting input data from keyboard. Second Thread to identify the ODD and EVEN list Third Thread to get descending ordered ODD list Fourth Thread to get ascending ordered EVEN list Input data: 56, 23, 12, 64, 87, 02, 45, 88, 35, 67	6 hours
4.	Write a Vx Works code for the given scenario. Also identify the proper mechanism to avoid this problem.	6 hours

	 • T1, T2, T3 and T4 → Tasks • R1, R2, R3 and R4 → Resources	
5.	Write a VxWorks code for the given scenario. Also identify the proper mechanism to avoid this problem. 	3 hours
	Total Laboratory Hours	30 hours
Mode of Evaluation: Continuous Assessment Test, Final Assessment Test		
Recommended by Board of Study : 27/02/2016		
Approved by Academic Council : No:40 Date : 18/03/2016		

Programme Elective

Course Code	Course Title	L	T	P	J	C
ECE6036	IN-VEHICLE NETWORKING	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version ~~1.2~~				

Course Objectives:

The course aimed at

1. Providing students a working knowledge of in-vehicle network systems
2. Giving an exposure to aspects of design, development, application and performance issues associated with in vehicle networking systems.
3. Illustrating concepts of sensor data capture, storage and exchange of data to access remote services

Expected Course Outcome:

The students will be able to

1. Know the need for In Vehicle Networking and the basics of data communication and networking concepts.
2. Comprehend protocols like CAN used in automotive applications.
3. Have an overview of the CAN higher layer protocols like CAN open, Device Net, TTCAN and SAE J1939.
4. Understand the working mechanism of LIN protocol.
5. Get an overview of MOST protocol used in automotive for multimedia applications.
6. Comprehend protocols like FlexRay used in automotive for fault tolerant applications.
7. Comprehend the general protocols and their usage in automotive sector

Module:1	Concepts of In-vehicle networking	6 hours	

Overview of Data communication and networking–need for In-Vehicle networking–layers of OSI reference model–multiplexing and de-multiplexing concepts–vehicle buses.

Module:2	Networks and protocols	8 hours	

CAN protocol: principles of data exchange–real time data transmission–message frame formats, bit encoding–bit-timing and synchronization–data rate and bus length–network topology–bus access–physical layer standards.

Module:3	CAN higher layer protocol	6 hours	

Introduction to CAN open –Device net–TTCAN–SAEJ1939–overview of CAN open and applications in transportation electronics–CAN open standards).

Module:4	LIN protocol	5 hours	

LIN standard overview – applications – LIN communication concept message frame–development flow.

Module:5	MOST	5 hours	

MOST overview–data rates–data types–topology –application areas.

Module:6	FlexRay	6 hours	

Flex Ray introduction–network topology–ECU sand bus interfaces–controller host interface and protocol operation controls–media access control and frame and symbol processing–coding/decoding unit–Flex Ray scheduling–message processing– wakeup/startup–applications.

Module:7	**General purpose protocols**	**7 hours**	
GSM- WiFi – Bluetooth and NFC Implementation –Ethernet, TCP, UDP, IP.			
Module:8	**Contemporary issues:**	**2 hours**	
	Total Lecture hours:	**45 hours**	

Text Book(s)	
1.	Dominique Paret, Multiplexed Networks for Embedded Systems CAN, LIN, FlexRay, Safe by-Wire, 2014, 1st edition, Wiley, United States.
Reference Books	
1.	Chung Ming Huang, YuhShyan Chen, Telematics Communication Technologies and Vehicular Networks: Wireless Architectures and Application, 2010, 1st edition, Information Science Reference, United States.
2.	Ronald K Jurgen, Distributed Automotive Embedded Systems, 2010, 4th Edition, SAE International, United States.
3.	Richard Zurawski, Industrial Communication Technology Handbook, 2015, 2nd Edition, CRC press, United States.
4.	Konrad Reif, Automotive Mechatronics: Automotive Networking, Driving Stability Systems Electronics, 2015, 2nd Edition, Springer, United States.
Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.	

Recommended by Board of Studies		12/09/2020	
Approved by Academic Council	No. 59th	Date	24-09-2020

Course Code	Course Title	L	T	P	J	C
ECE6042	WIRELESS AND MOBILE COMMUNICATIONS	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version 1.1				

Course Objectives:

The course aimed at

1. To know about wireless mobile communication system & related issues, and
2. To keep abreast of the future of mobile communication

Expected Course Outcome:

The students will be able to

1. Get introduced Cellular Mobile Communication systems
2. Understand and solve telecommunication design issues using cellular and trunking theory.
3. Analyze the effect of multipath channels and suggest a suitable model for indoor or outdoor applications.
4. Demonstrate the implications of multipath parameters in mobile communication.
5. Will train the Channel coding for Mobile Radio
6. Interpret the Modulation techniques for Mobile Radio
7. Get introduced to Advanced Communication Systems and Wireless Standards

Module:1	Cellular Mobile Systems	4 hours	

Cellular Mobile Communication Evolution - Types of mobile wireless services/systems – 1G & 2G Mobile Communication Technology

Module:2	Cellular Concept	7 hours	

Cellular concept – Frequency reuse – Channel assignment strategies – Handoff strategies – Interference & system capacity – Trunking & Grade of service – Improving coverage and capacity in cellular system.

Module:3	Mobile Radio Propagation	9 hours	

Free Space Propagation Model – Basic Propagation mechanism – Two Ray Ground Reflection (Two Ray) model – Outdoor Propagation Models: Okumura Model, Hata Model – Indoor Propagation Model: Attenuation Factor Model.

Module:4	Small Scale Propagation models	4 hours	

Parameters of mobile multipath channels – Types of small scale fading – Fading effects due to Multipath time delay spread and Doppler spread

Module:5	Information Theory and Coding	6 hours	

Information and entropy - Coding of memoryless sources: Shannon-Fano / Huffman coding - Sources with memory: Markov model – Source Coding: Linear and non-linear quantisation, companding - Channel Coding: Convolutional coding, Viterbi decoding, LBC, Turbo Codes.

Module:6	Multiplexing & Modulation Schemes	6 hours	

FDMA, TDMA, CDMA, QPSK, WCDMA, OFDM/OFDMA, MC CDMA and SC FDMA, CP-OFDM and DFT-s-OFD (16QAM, 64QAM, 256QAM)

Module:7	**Advanced Communication Systems and Wireless Standards**	**7 hours**	
3G, 4G and 5G and beyond wireless standards – WLAN Architecture design and WIMAX – VANETS			
Module:8	**Contemporary issues:**	**2 hours**	
	Total Lecture hours:	**45 hours**	

Text Book(s)	
1.	Randy L. Haupt, Wireless Communications Systems: An Introduction, Wiley-IEEE Press, January 2020.
2.	T.S.Rappaport, Wireless Communication -Principle and Practice ,Prentice Hall, 2010.
Reference Books	
1.	W.C.Y.Lee, Wireless and Cellular Communication, McGraw Hill, 2006
2.	Schiller, Mobile Communications; Pearson Education Asia Ltd., 2008
Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.	

Recommended by Board of Studies		12/09/2020	
Approved by Academic Council	No. 59th	Date	24/09/2020

Course Code	Course Title	L	T	P	J	C
ECE6043	ADVANCED PROCESSORS AND ITS APPLICATIONS	2	0	0	4	3

Pre-requisite	Nil	Syllabus Version 1.1

Course Objectives:

The course is aimed at

1. Providing a complete understanding of the ARM Cortex architecture.
2. Imparting the knowledge of programming ARM Cortex architecture.
3. Providing knowledge on programmable DSPs Architecture, On-chip Peripherals and Instruction set.

Expected Course Outcome:

The students will be able to

1. Learn the architecture and instruction set of ARM Cortex M4.
2. Program GPIOs and Interrupts of an ARM cortex M4.
3. Develop applications based on Timers, PWM and ADC with ARM cortex M4.
4. Understand and program the various communication modules of ARM Cortex M4.
5. Acquire knowledge about ARM Cortex A architecture.
6. Comprehend programming of ARM 64 bit architecture.
7. Demonstrate their ability to program the DSP processor for signal processing applications.
8. Design application for various social relevant and real time issues.

Module:1	ARM architecture and Cortex – M series	4 hours	

Introduction to the ARM Cortex M4 and its targeted applications, ARM Cortex M4 architecture address space, on- chip peripherals (analog and digital) Register sets, addressing modes and instruction set basics.

Module:2	Microcontroller Programming	6 hours	

ARM Cortex M4: I/O pin multiplexing, pull up/down registers, GPIO control, Memory Mapped Peripherals, programming System registers. Introduction to Interrupts, Interrupt vector table, interrupt programming.

Module:3	Timers, PWM and Mixed Signals Processing	4 hours	

Timer, Basic Timer, Real Time Clock (RTC), Timing generation and measurements, ADC. PWM Module & Quadrature Encoder Interface (QEI).

Module:4	Communication protocols and Interfacing with external devices	4 hours	

I2C protocol, SPI protocol, USB & UART protocol. Implementing and programming I2C, SPI, USB & UART interface.

Module:5	ARM Cortex A Architecture	4 hours	

Introduction to ARMv8-A, ARMv8-A Memory Management, ARMv8-A Memory Model, Caches and Branch Prediction, Synchronization and Cache coherency.

Module:6	Software Engineers guide to ARM Cortex 64 bit architecture	2 hours	

Booting, Power Management, Virtualization, Security, Debugging.

Module:7	**DSP Processors**	**4 hours**	
Architecture of TMS320CXX Processor – Addressing modes – Assembly language Instructions – Assembler directives, Pipeline structure, On-chip Peripherals – Block Diagram of DSP starter kit (DSK) – Software Tools, DSK on-board peripherals, – Code Composer Studio – Support Files - Application Programs for processing real time signals.			
Module:8	**Contemporary issues:**	**2 hours**	
	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	Joseph Yiu, "The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors", 2013, 3rd Edition, Newnes ,UK.
2.	ARM Cortex-A Series Programmer's Guide for ARMv8-A Version: 1.0, 2015, ARM, United States.
3.	James A Langbridge, "Professional Embedded ARM Development", 2014,1st Edition, John Wiley Sons & Inc., United States.
4.	Jonathan W. Valvono "Introduction to ARM Cortex-M Microcontrollers", 2014, 5th Edition, Create Space Independent Publishing Platform, United States.
5	Rulph Chassaing and Donald Reay, Digital Signal Processing and Applications with the C6713 and C6416 DSK, John Wiley and Sons, Inc., Publication, 2012 (Reprint).

Reference Books	
1.	Harris and Harris, Digital Design and Computer Architecture: ARM Edition, 2015, Morgan Kaufmann, , United States.
2.	Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C, 2015, 2nd Edition, E-Man Press LLC, United States.
3.	Avtar Singh and S. Srinivasan, Digital Signal Processing – Implementations using DSP Microprocessors with Examples from TMS320C54xx, Cengage Learning India Private Limited, Delhi 2012.
4.	B. Venkataramani and M. Bhaskar, Digital Signal Processors – Architecture, Programming and Applications – Tata McGraw – Hill Publishing Company Limited. New Delhi, 2003.

Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.

Typical Projects:

1. Adaptive Temporal Attenuator using C5x/C6x.
2. Filter Design and Implementation using a Modified Prony's Method.
3. Voice Detection and Reverse Playback using C5x/C6x.
4. Acoustic Direction Tracker using C5x/C6x.
5. Multirate Filter using C5x/C6x.
6. Four-Channel Multiplexer for Fast Data Acquisition using C5x/C6x.
7. Video Line Rate Analysis using C5x/C6x.
8. Implementation of FIR High Pass Filter using ARM Cortex-M4 microcontroller.
9. Parametric Equalizer using STM32 microcontroller.
10. Noise Reduction using Moving Sum Filtering using STM32F407 Cortex M4 microcontroller.
11. Implementation of Audio CODEC on STM32F4 microcontroller.

12. Motor Control using PID-Controller on STM32F407 microcontroller.			
Mode of Evaluation: Project Reviews I,II,III			
Recommended by Board of Studies		12/09/2020	
Approved by Academic Council	No. 59th	Date:	24/09/2020

ECE6044	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**Nil**	**Syllabus Version :**				

Course Objectives:

The course is aimed at

[1] Imparting knowledge about EMI environment

[2] Teaching EMI coupling principles, EMI control techniques and design of PCBs for EMC

[3] Giving exposure to EMI Standards, Regulations and Measurements

Expected Course Outcome:

At the end of the course, the students will be able to

[1]Understand terminologies of EMI and EMC

[2]Analyze and understand various EMI coupling mechanisms

[3]List various EMI Test and Measurement methods

[4] Analyze various techniques needed to suppress EMI

[5]Perceive different EMC regulations followed worldwide

[6]Ability to design an Electromagnetic Compatible systems.

[7]Analyze and comprehend different techniques needed for Signal Integrity and ability to understand various models for EMI/EMC

Module:1	**EMI Environment**	**4 hours**	

EMI-EMC Definitions and units of Parameters, Sources of EMI, conducted and radiated EMI, Transient EMI

Module:2	**EMI Coupling Mechanisms**	**6 hours**	

Conducted, Radiated and Transient Coupling, Common Impedance Ground Coupling, Radiated Common Mode and Ground Loop Coupling, Radiated Differential Mode Coupling,

Near Field Cable to Cable Coupling, Power Mains and Power Supply Coupling.

Module:3	**EMI Test and Measurements**	**8 hours**	

EMI Specification / Standards / Limits: Units of specifications, Civilian standards Military standards. EMI Test Instruments/Systems, EMI Test, EMI Shielded Chamber, Open Area Test Site, TEM Cell Antennas, Conductors Sensors/Injectors/Couplers. EMI Measurement

Methods: Military Test Method and Procedures, Calibration Procedures, Modeling interferences.

Module:4	**EMI Control Techniques**	**7 hours**	

Shielding, Filtering, Grounding, Bonding, Isolation Transformer, Transient Suppressors, Cable Routing, Signal Control, Component Selection and Mounting, Electrostatic discharge protection schemes

Module:5	**EMC Standards and Regulations**	**5 hours**	

National and Intentional standardizing organizations- FCC, CISPR, ANSI, DOD, IEC, CENEEC, FCC CE and RE standards, CISPR, CE and RE Standards, IEC/EN, CS standards, SAE Automotive EMC standard, Frequency assignment - spectrum conversation.

Module:6	**System Design for EMC**	**8 hours**	

PCB Traces Cross Talk, Impedance Control, Power Distribution Decoupling, Zoning, Motherboard Designs and Propagation Delay Performance Models, System Enclosures, Power line filter placement, Interconnection and Number of Printed Circuit Boards, PCB and subsystem

decoupling			
Module:7	**Signal Integrity and EMI/EMC Models**	**5 hours**	
Effect of terminations on line wave forms, Matching schemes for Signal Integrity, Effects of line discontinuities, Statistical EMI/EMC models.			
Module:8	**Contemporary issues:**	**2 hours**	
	Total Lecture hours:	**45 hours**	

Text Book(s)

1. Clayton R. Paul, Introduction to Electromagnetic compatibility, 2010, 2nd ed., Wiley & Sons, New Jersey

Reference Books

1. Henry W.ott , Electromagnetic Compatibility Engineering, 2011, 1st ed., John Wiley and Sons, New Jersey.
2. Patrick G. André and Kenneth Wyatt, EMI Troubleshooting Cookbook for Product Designers 2014, 1st ed., SciTech Publishing, New Jersey

Recommended by Board of Studies : 12/09/2020

Approved by Academic Council : No: 59th Date : 24-09-2020

Course Code	Course Title	L	T	P	J	C
ECE5045	ADVANCED DIGITAL IMAGE PROCESSING	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version : ~~1.2~~				

Course Objectives:

The course is aimed at

[1] Revising the basics of digital image processing namely; image acquisition, digitizing, enhancing images in spatial domain, image transforms and enhancing images in frequency domain.

[2] Enabling the students to acquire knowledge in image restoration, image compression, image segmentation and object recognition.

[3] Motivating the students to apply image processing and classification algorithms for solving real life problems and introducing students to upcoming trends in Computer Vision.

Course Outcomes (CO):

At the end of the course the student will be able to

[1] Comprehend the image acquisition, digitization, and processing in spatial domain.

[2] Understand algorithms and programs for processing an image in transform domain

[3] Acquaint with the image enhancement and restoration techniques

[4] Implement different compression techniques to compress an image

[5] Adopt different segmentation and image representation techniques for image processing.

[6] Understand the pattern recognition approaches for implementing the visual system.

[7] Identify computer vision techniques in various real-time applications.

Module:1	Image Processing in Spatial Domain	7 hours	

Fundamental steps in DIP – Elements of visual perception - Image Sampling and Quantization - Basic relationship between pixels. Image enhancement - Spatial Domain: Basic Grey level Transformations – Histogram Processing – Smoothing spatial filters- Sharpening spatial filters. Colour image Processing: Models, Transformation

Module:2	Image Transforms	6 hours	

Image Transforms: Two dimensional Fourier Transform- Discrete cosine transform - Multi-resolution analysis – Haar Transform- Discrete Wavelet Transform. Karhunen-Loeve transform. and SVD

Module:3	**Frequency domain filtering and Image Restoration**	**6 hours**	
Smoothing frequency domain filters- sharpening frequency domain filters- Homomorphic filtering. *Image Restoration*: Image deformation and geometric transformations, Restoration techniques, Noise characterization, Linear, Position invariant degradations, Adaptive filters.			
Module:4	**Image Compression**	**6 hours**	
Image Compression Techniques- Lossy and Lossless compression- Entropy Encoding-JPEG and MPEG standards			
Module:5	**Image Segmentation**	**7 hours**	
Detection of discontinuities – point, corner, edge detection- thresholding -edge based segmentation-region based segmentation- morphological segmentation - watershed algorithm Descriptors: Boundary descriptors-Region descriptors- Texture descriptors, RANSAC.			
Module:6	**RECOGNITION and CLASSIFICATION**	**7 hours**	
Patterns and pattern classes – Introduction to classification – Decision theoretic methods – structural and syntactic classifiers – Clustering techniques – similarity measures – hierarchical methods – K-Means algorithm – Cluster evaluation methods. Convolution neural networks, Region-based CNN, fully convolution networks, Multi-modal networks, Hybrid learning methods.			
Module:7	**COMPUTER VISION APPLICATIONS**	**4 hours**	
Face recognition application: personal photo collections – Instance recognition application : Location recognition – Machine learning applications: Deep voting, transfer learning and structured regression for image analysis and categorization.			
Module:8	**Contemporary issues:**	**2 hours**	
			Total Lecture hours: 45 hrs

Text Book(s)

1. Rafael C. Gonzalez & Richard E. Woods, "Digital Image Processing", 4th Edition, 2018, Pearson, USA
2. David A. Forsyth and Jean Ponce, "Computer Vision: A Modern Approach", 2nd Edition, 2012, Prentice Hall, Pearson Education

Reference Books

1. Richard Szeliski, "Computer vision: Algorithm and Applications", Springer- Verlag, London, 2010.
2. Anil K. Jain, Fundamentals of Digital Image Processing, 2015, 3rd Edition, Pearson Education, USA.
3. K.P.Soman, K.I. Ramchandran, N.G.Resmi, Insights into Wavelets, From Theory to Practice, 2013, 3rd Edition, PHI Learning Private Limited, New Delhi, India.
4. Mark Nixon & Alberto Aguado, Feature Extraction, and Image Processing, 2013, 3rd Edition, Elsevier's Science& Technology Publications, USA
5. William K. Pratt, Digital Image Processing, 2013, John Wiley & Sons, USA.

Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.

Recommended by Board of Studies : 12/09/2020

Approved by Academic Council : 59th Date : 24/09/2020

Course Code	Course Title	L	T	P	J	C
ECE6037	FAULT TOLERANT AND DEPENDABLE SYSTEMS	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version :				

Course Objectives:

The course is aimed at

[1] Providing students with a working knowledge of the potential faults and errors occurring in an embedded system.

[2] Providing knowledge in concepts of fault detection and fault tolerance.

[3] Teaching students dependability concepts

[4] Exposing the fault tolerance strategies and design techniques.

Course Outcomes (CO):

At the end of the course the student will be able to

[1] Gain knowledge in concepts involving fault detection

[2] Comprehend dependability concepts

[3] Understand tolerance and correction mechanisms in real world scenarios.

[4] Design and develop dependable systems for mission critical applications.

[5] Understand Fault tolerance in interconnected systems.

[6] Understand Fault tolerance in distributed systems.

[7] Apply Dependability evaluation techniques and tools

Module:1	**Faults and Failures**	**4 hours**	
Fault - error, failure - faults and their manifestation - classification of faults and failures			
Module:2	**Dependability Concepts**	**5 hours**	
Dependable system - techniques for achieving dependability - dependability measures			
Module:3	**Fault Tolerance Strategies**	**6 hours**	
Fault detection – masking – containment – location – reconfiguration - recovery.			
Module:4	**Fault tolerant design techniques**	**8 hours**	
Hardware redundancy - software redundancy - time redundancy - information redundancy			
Module:5	**Fault tolerance in Interconnects**	**6 hours**	
Hypercube - star graphs - fault tolerant ATM switches			
Module:6	**Fault Tolerance in Distributed Systems**	**8 hours**	
Byzantine General problem - consensus protocols - check pointing and recovery - stable storage and RAID architectures - data replication and resiliency			
Module:7	**Dependability evaluation techniques and tools**	**6 hours**	
Fault trees - Markov chains - HIMAP tool			
Module:8	**Contemporary issues:**	**2 hours**	

Total Lecture hours: 45 hours

Text Book(s)

1. Israel Koren, C. Mani Krishna, Fault-Tolerant Systems, 2011, Morgan Kaufmann, San Francisco.
2. Elena Dubrova, Fault-Tolerant Design, 2013, Springer, Sweden.

Reference Books

1. D. P. Siewiorek and R. S. Swarz, Reliable Computer Systems: Design and Evaluation, 2014, 3rd ed., Digital Press, Pennsylvania.

2. Alessandro Birolini, Reliability Engineering: Theory and Practice, 2017, 8th ed., Springer-Verlag Berlin Heidelberg, Spain.

Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.	
Recommended by Board of Studies : 12/09/2020	
Approved by Academic Council : No. 59th	Date : 24/09/2020

Course Code	Course Title	L	T	P	J	C
ECE6046	ADVANCED EMBEDDED PROGRAMMING	3	0	0	0	3
Pre-requisite	Nil					

Course Objectives:

The course is aimed at making the students

[1] To learn advanced programming skills of the Embedded C and Linux and the range of embedded applications.

[2] To develop skills and understand the embedded Linux device drivers.

Expected Course Outcome:

At the end of the course, the student will be able to

[1] Develop character driver.

[2] Gain knowledge about advanced device driver functions.

[3] Comprehend Linux device model

[4] Comprehend interrupt handlers in device drivers

[5] Debug a device driver code

[6] Develop I/O management

[7] Develop USB in device driver

Module:1	**Basic Device driver review**	**6 hours**	
Boot loader, Driver concepts -Block & character driver distinction -Low level drivers, OS drivers etc -Writing character drivers - Device major, minor number.			
Module:2	**Advanced Device driver characteristics**	**6 hours**	
Interfaces to driver read, write, ioctl etc-Blocking and non-blocking calls, Synchronisation - Semaphores , mutexes ,spinlocks –Proc & Sysfs interfaces			
Module:3	**The Linux Device Model**	**6 hours**	
K objects, K sets, and Subsystems ,Low-Level Sysfs Operations, Hot plug Event Generation Buses, Devices, and Drivers, Classes, Putting It All Together, Hot plug, Dealing with Firmware			
Module:4	**Interrupt Handling**	**6 hours**	
Interrupts and bottom halves -Writing interrupt driven drivers, Implementing bottom halves-Kernel Threads & Work Queues			
Module:5	**Time Delays and Debugging Techniques**	**6 hours**	
Timers, Kernel timers, Jiffies , Timer interrupts- Debugging using printing, querying, watching and system defaults-Debugging tools			
Module:6	**Communicating with Hardware**	**6 hours**	
I/O Mapped I/O, Memory mapped I/O, Understanding DMA operations.			
Module:7	**USB Driver Model**	**7 hours**	
USB Device Basics, USB and Sysfs, USB Urbs, Writing a USB Driver, USB Transfers without Urbs.			
Module:8	**Contemporary issues:**	**2 hours**	
	Total Lecture hours:	**45 hours**	

Text Book(s)

1. 1. John Madieu, Linux Device Drivers Development,, 2017, www.packt.com.

2. Mohan Lal Jangir, Linux Kernel and Device Driver Programming, 2014, 1st Edition, University Science Press, India

Reference Books			
1. Mastering Embedded Linux Programming, 2017, 2nd Edition, Packt Publishing, UK. 2. Derek Molloy, Exploring Beagle Bone: Tools and Techniques for Building with Embedded Linux, 2015, 1st Edition, Wiley Publications, USA.			
Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.			
Recommended by Board of Studies		27/02/2016	
Approved by Academic Council	No. 40	Date	18/03/2016

Course code	Course title	L	T	P	J	C
ECE 6047	DESIGN AND ANALYSIS OF ALGORITHM	3	0	0	4	4
Pre-requisite		Syllabus version :1				

Course Objectives:

This course is aimed at

[1] Enabling the students to carry out analysis of various algorithms for mainly time and space complexity.

[2] Teaching the students how to decide the appropriate data type and data structure for a given problem.

[3] Teaching the students how to select the best algorithm to solve a problem by considering various problem characteristics, such as the data size, the type of operations, etc.

Expected Course Outcome:

At the end if this course, the student will be able to

[1] Develop proficiency in problem solving and programming.

[2] Comprehend Combinatorial Optimization

[3] Analyse various algorithms for mainly time and space complexity.

[4] Comprehend Cryptographic Algorithms

[5] Learn Geometric Algorithms

[6] Analyse Parallel Algorithms

[7] Analyse and evaluate the given program in terms of code size and computational time.

[8] Select the best algorithm to solve a problem by considering various problem characteristics, such as the data size, the type of operations, etc.

Module:1	**Introduction:**	**7 hours**	

Role of Algorithms in computing, Analysis of Algorithms, Asymptotic notation, Euclid's algorithm, Problem, Instance, RAM model, Principles of Algorithm Design, Sorting Algorithm - Insertion Sort & Complexity Analysis, Divide and Conquer Technique, Solving recurrences - substitution, Iteration, Recursion tree, Changing variable and Master's Method.

Module:2	**Combinatorial Optimization:**	**5 hours**	

Backtracking; Dynamic programming; Greedy Technique ; Branch & Bound

Module:3	**Advanced Algorithmic Analysis:**	**5 hours**	

Amortized analysis; Online and offline algorithms; Randomized algorithms, NP Completeness

Module:4	**Cryptographic Algorithms:**	**9 hours**	

Historical overview of cryptography; Private-key cryptography and the key-exchange problem; Public-key cryptography; Digital signatures; Security protocols; Applications (zero-knowledge proofs, authentication etc..

Module:5	**Geometric Algorithms:**	**7 hours**	

Line segments: properties, intersections; convex hull finding algorithms, Voronoi Diagram, Delaunay Triangulation

Module:6	**Parallel Algorithms:**	**5 hours**	

PRAM model; Exclusive versus concurrent reads and writes; Pointer jumping; Brent's theorem and work efficiency

Module:7	**Distributed Algorithms:**	**5 hours**	

Consensus and election; Termination detection; Fault tolerance; Stabilization;

Module:8	**Contemporary issues:**	**2 hours**	
Total Lecture hours:			**45 hours**

Text Book(s)

1.Anany Levitin, "Introduction to the Design and Analysis of Algorithms". 3rd edition.,2011, Addison Wesley , 2011

2. Cormen, Leiserson, Rivest and Stein , "Introduction to Algorithms", 3rd edition, McGraw-Hill, 2009

Reference Books

1. Ellis Horowitz, "Fundamentals of Computer Algorithms", 2nd Edition, Universities Press, 2008

2. M. J. Quinn, Parallel computing – theory and practice, McGraw Hill, 2002

3. Sukumar Ghosh, "Distributed Systems: An Algorithmic Approach" ,1st edition, Chapman & Hall/CRC Computer & Information Science Series, 2006

4. William Stallings, "Cryptography & Network Security", 4th Edition , Prentice Hall, 2005

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Projects (Indicative)

I. Robot Motion Planning Based Projects to apply Computational Geometric Algorithm Principles

II. Explore Searching Algorithms : Get into the interiors of indexing, page ranking search algorithms

III. Design, analyze, implement and experiment new algorithms and software for solving optimization problems arising in the area of Robotics, Gaming, Telecommunication, Automotive, Genetics, Medical Applications etc.

IV. Implement the Algorithm to cater a requirement in Military Application. The chief-commander encrypts the command and communicates to soldiers by using DES. His command contains the data in encrypted form. Also decipher this encrypted command at the receiver.

V. Implement the RSA Based Digital Signature scheme

VI. Implement & Build Distributed Web Service Access (Ex : Currency Convertor)

VII. Implement the algorithm for scheduling independent parallel tasks.

VIII. Implement & Solve the following Algorithmic Puzzles using any Programming language

1. Place N chess queens on an N×N chessboard so that no two queens attack each other using BackTracking Approach
2. Implement an efficient Sudoku Solution : Given a partially filled 9×9 2D array 'grid[9][9]', the goal is to assign digits (from 1 to 9) to the empty cells so that every row, column, and subgrid of size 3×3 contains exactly one instance of the digits from 1 to 9.
3. Apply Recursive principles and implement Tower of Hanoi Puzzle.

   Tower of Hanoi is a mathematical puzzle where we have three rods and n disks. The objective of the puzzle is to move the entire stack to another rod, obeying the following simple rules:

   1) Only one disk can be moved at a time.

   2) Each move consists of taking the upper disk from one of the stacks and placing it on top of another stack i.e. a disk can only be moved if it is the uppermost disk on a stack.

   3) No disk may be placed on top of a smaller disk
4. Implement an efficient program to solve the Egg Drop Puzzle involving n=2 eggs and a building with k=36 floors.

   Suppose that we wish to know which stories in a 36-story building are safe to drop eggs from, and which will cause the eggs to break on landing. We make a few assumptions:

- An egg that survives a fall can be used again.
- A broken egg must be discarded.
- The effect of a fall is the same for all eggs.
- If an egg breaks when dropped, then it would break if dropped from a higher floor.
- If an egg survives a fall then it would survive a shorter fall.
- It is not ruled out that the first-floor windows break eggs, nor is it ruled out that the 36th-floor do not cause an egg to break.

If only one egg is available and we wish to be sure of obtaining the right result, the experiment can be carried out in only one way. Drop the egg from the first-floor window; if it survives, drop it from the second floor window. Continue upward until it breaks. In the worst case, this method may require 36 droppings. Suppose 2 eggs are available. What is the least number of egg-droppings that is guaranteed to work in all cases?

Implement an efficient algorithm to solve the puzzle : A man finds himself on a riverbank with a wolf, a goat, and a head of cabbage. He needs to transport all three to the other side of the river in his boat. However, the boat has room for only the man himself and one other item (either the wolf,the goat,or the cabbage).In his absence, the wolf would eat the goat, and the goat would eat the cabbage. Show how the man can get all these "passengers" to the other side

Mode of evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test, Project Reviews I, II, III			
Recommended by Board of Studies	27/02/2016		
Approved by Academic Council	No. 40	Date	18/03/2016

Course Code	Course Title	L	T	P	J	C
ECE6038	VIRTUAL INSTRUMENTATION SYSTEMS	0	0	4	4	3
Pre-requisite	Nil					

Course Objectives:

The course is aimed at

[1] Introducing students on Graphical programming concepts

[2]Exposing students to system design using block level approach

[3]Providing basic knowledge about Data Acquisition

[4]Developing and solve real life problem using lab view NI based systems

Course Outcomes (CO):

At the end of the course the student should be able to

[1] Acquire knowledge about Graphical Programming and able to differentiate from conventional programming

[2]Learn about basics of Graphical Programming and its structure

[3]Understand process of data acquisition using hardware

[4]Provide a solution to engineering problem using virtual instrumentation system

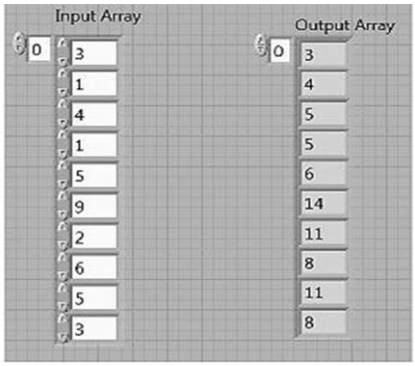
Reference Books

1.Jovitha Jerome Virtual Instrumentation Using LabVIEW, 2010, 1st ed., PHI Learning, India.

Text Book(s)

1.Ian Fairweather, Anne Brumfield, LabVIEW: A Developer's Guide to Real World Integration, 2011, 1st ed., CRC Press, USA.

List of Challenging Experiments (Indicative)

1.	**Introduction:** Generalfunctionaldescription ofadigitalinstrument-BlockdiagramofaVirtual Instrument, AdvantagesofVirtualinstruments overconventionalinstruments-Architecture ofaVirtualinstrument anditsrelationtotheoperatingsystem, LabVIEW – Graphicaluserinterfaces-ControlsandIndicators, 'G'programming – LabelsandText-Shape, SizeandColor – Ownedandfreelabels **Lab Exercise:** Examine the following image and develop a VI for the same 	8 hours
2.	**Graphical Language:** Datatype, Format,Precisionand representation-Datatypes -Dataflowprogramming, Graphical programming palettes and tools - Front panel objects - Functions and Libraries	8 hours

	Lab Exercises: 1) Use a while loop and a waveform chart to build a VI that demonstrates software timing 2) Develop a VI to generate a RAMP signal as shown below Input to the VI are Min, Max, Time span[initial value as 0 and end value only need to give] and the last input is the number of data points. VI takes the difference between Max and Min and divides that interval by the number of data points (# Points) that the user requires. For example this would mean that the user requires 5000 points to span the difference between 0 and 10[time span]. In other words, the value of the ramp function at the *i*th point is ((10-0)/5000)* *i*. The For Loop allows traversing through the values of i from 0 to 5000.	
3.	**Programming Structure:** FORloops,WHILEloops, CASEstructure, formulanodes,Sequence structures-ArraysandClusters-Array operations-Bundle-Bundle/Unbundlebyname,graphsand charts **Lab Exercises:** 1) Using Error Clusters & Handling to find square root 2) To design an interface to measure temperature and check its range between • 0 to 30 • 30 to 60 • more than 60 Record the highest and lowest temperature. Have a switch to record the selected temperature ranges.	16 hours
4.	**Handling Strings:** StringandfileI/O-HighlevelandLowlevelfileI/O's-AttributemodesLocalandGlobal variables **Lab Exercises:** 1) Design a case structured calculator using string as input cases. 2) Build a VI that creates an array of random numbers, scales the resulting array, and takes a subset of that final array. You create a For Loop that runs for 10 iterations. Eachiteration generates a random number and stores it at the output tunnel. Random Array displays an array of 10 random numbers. The VI multiplies each value in Random Array by a Scaling Factor to create another array called Final Array. The VI then takes a subset of the Final Array starting at Start Subset for # of Elements and displays the subset in Subset Array	12 hours
5.	**Hardware Aspects:** Addressingthe hardwarein LabVIEW-DigitalandAnalog I/Ofunction- DataAcquisition-BufferedI/O-RealtimeData Acquisition **Lab Exercises:** Build a Temperature Monitoring VI that continuously measures the temperature once per time unit [variable] and displays the temperature. If the temperature goes above or below the preset limits, the VI turns on a front	8 hours

	panel LED. You should be able to set the limit from the front panel. Also modify the temperature monitoring VI so that it records both the highest and lowest recorded temperatures, and also displays the time elapsed (in seconds) since recording began. Add a save option to your temperature-monitoring VI as explained above. The user will have the option to save the acquired data into a spreadsheet file that will also include additional information like the user name. Below shown is the Front panel for your reference	
6.	**Case Studies:** **Lab Exercises:** 1) Interface a temperature sensor to microcontroller, acquire the sensor data and display it in labview 2) Interface a motor to microcontroller and control the speed of it through labview.	8 hours
	Total Laboratory Hours	64 hours

Mode of Evaluation:Continuous Assessment Test and Final Assessment Test

Typical Projects:

1. Develop a labview based system that controls the speed of a Motor. The motor is interfaced to any Microcontroller which supports the USB communication. In Labview create a UI with slider. The slider in the UI must be used for controlling the speed of motor.
2. Develop an UI in labview that will generate a different pattern based on the random number generated by a random function in labview. The generated pattern must be send out via USB and the same will get displayed in LED's interfaced with a microcontroller.
3. Develop an UI in Labview which depicts the signal generator functionality. A microcontroller is interfaced with labview and an oscilloscope must be interfaced to capture the signals which are given as an input in UI developed in Labview.
4. Develop an UI in labview which acquire the sensor data and store it in an Excel sheet of PC. The sensors are interfaced to microcontroller and the microcontroller is interfaced to labview system via USB

Mode of Evaluation: Continuous Assessment Test, Final Assessment Test	
Recommended by Board of Studies : 27/02/2016	
Approved by Academic Council : No:40	18/03/2016

Course code	Course title	L	T	P	J	C
ECE6048	EMBEDDED SYSTEM DESIGN USING FPGA	2	0	0	4	3
Pre-requisite	Nil	Syllabus version:1				

Course Objectives:

The course is aimed at

[1] Provide in depth understanding of logic and system design.

[2] Enabling the students to apply their knowledge for the design of advanced digital hardware systems with help of FPGA tools

[3] Teaching the students scheduling and communication with respect to FPGA

Expected Course Outcome:

At the end of the course, the Students will be able to

[1] Comprehend overview of Embedded System

[2] Learn Hardware Description Languages

[3] Acquire abilities to Design an embedded system using FPGA

[4] Use Xilinx IP Cores

[5] Comprehend Partitioning concepts

[6] Comprehend Scheduling & Communication

[7] Identify and exploitation of Parallelism concepts

[8] Use state-of-art hardware and software to solve real life problems

Module:1	**Embedded System Overview**	**4 hours**	
H/W-FPGA-Embedded SoC and use of VLSI circuit technology-platform FPGA's-Altera Cyclone			
Module:2	**Hardware Description Languages**	**4 hours**	
Hardware Description Languages - VHDL , Verilog , Other High-Level HDLs, From HDL to Configuration Bit-stream			
Module:3	**System Design using FPGA**	**4 hours**	
Principles of system design-Design quality, Modules and interfaces, Abstraction and state, Cohesion and coupling, Designing and Reuse, Control flow graph, Design-Origins of platform FPGA designs			
Module:4	**FPGA Platform**	**4 hours**	
Components, Adding to platform FPGA systems, assembling custom compute cores. Software Design-System Software Options, Root File system, Cross-Development Tools, Monitors and Boot-loader.			
Module:5	**Partitioning**	**4 hours**	
Overview of Partitioning Problem, Analytical Solution to Partitioning-Basic definitions, Expected performance gain, Resource considerations, Analytical Approach			
Module:6	**Scheduling & Communication**	**4 hours**	
Communication-Invocation/Coordination, Transfer of State, Practical Issues- Profiling Issues, Data Structures Manipulate Feature Size.			
Module:7	**Spatial Design**	**4 hours**	
Principles of Parallelism-Identifying Parallelism - Spatial Parallelism with Platform FPGAs-Parallelism within FPGA Hardware Cores, Parallelism within FPGA Designs			
Module:8	**Contemporary issues:**	**2hours**	
	Total Lecture hours:	**30 hours**	

Text Book(s)

1. Ron Sass, Andrew G Schmidt Embedded Systems Design with Platform FPGAs Principles and Practices, 2011, First Edition, Tata McGraw Hill, India.

Reference Books

1. Charles H Roth. Jr Digital Systems design using VHDL, 2012, Re-Print, PWS publishing company (Thomson Books), USA.
2. V A. Padroni Circuit Design with VHDL 2011, First Edition, MIT Press Cambridge, England.

3. Wayne Wolf, FPGA Based System Design, 2011, First Edition, Prentices Hall Modern Semiconductor Design Series, USA.

Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test

Typical Projects

1.Bluetooth based home automation using FPGA.A Bluetooth mobile app need to be developed to transfer control information to the Bluetooth receiver which is to be interfaced with the FPGA board. Based upon the received data, the household devices like lamp, fan etc. should be turned ON/OFF.

2.Implement an Interrupt Controller (8259) using FPGA. The entire functional block should be sub divided into various modules like vector address module, command register module, mask register module and finally it need to be integrated into a single unit to accomplish specified tasks

3. Implement a general purpose processor on FPGA. The purpose of the design is to build an FPGA with the following features: a CPU similar to the Atmel ATmega8, a serial port with a fixed baud rate, and an output for a single digit 7-segment display.

4. Real-time hardware implementation of a motion detection algorithm for vision based automated surveillance systems. The working prototype of a complete standalone automated video surveillance system, including input camera interface, designed motion detection VLSI architecture, and output display interface, with real-time relevant motion detection capabilities, need to be implemented on FPGA

Mode of Evaluation: Project Reviews I, II, III

Recommended by Board of Studies	27/02/2016		
Approved by Academic Council	No. 40	Date	18/03/2016

Course Code	Course Title	L	T	P	J	C
ECE5044	HARDWARE SOFTWARE CODESIGN	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version:1.1				

Course Objective:

The course is aimed at

[1] Providing adequate knowledge in the modeling of heterogeneous embedded systems based on design constraint and provide alternate solution exploring trade-off.

[2] Introducing the importance of estimating the cost analysis in terms of hardware and software parameters.

[3] Introducing various co-synthesis and co-simulation tools for the effective design of embedded systems with better communication between different modules.

Expected Course Outcome:

At the end of the course, the Students will be able to

[1] Apply different MOCs based on system design specification.

[2] Propose an alternate design solution based on constraint analysis.

[3] Identify the partitioning solution based on the algorithms.

[4] Understand various co-synthesis approaches.

[5] Ability to pre-estimate and estimate the performance metrics for hardware and software based on cost analysis.

[6] Approximate the pre-estimate and estimate the performance metrics for software based cost analysis.

[7] Decide on proper co-simulation method based on system specification.

Module:1	Specification of embedded systems	7	hours	

Introduction to Co-design - Comparison of co-design approaches – **Unified representation-Model** – MoCs: State oriented, Activity oriented, Structure oriented, Data oriented and Heterogeneous – Software CFSMs – Processor Characterization.

Module:2	HW/SW partitioning Constraints & tradeoffs	7	hours	

Cost modeling, Principle of hardware/software mapping - Real time scheduling - design specification & constraints on Embedded systems - Tradeoffs

Module:3	HW/SW partitioning methodologies	7	hours	

Partitioning-Types of partitioning-Partitioning granularity - Kernigan-Lin Algorithm - Extended Partitioning - Binary Partitioning: GCLP Algorithm

Module:4	Co-synthesis	7	hours	

Software synthesis – Hardware Synthesis - Interface Synthesis – Co-synthesis Approaches: Vulcan, Cosyma, Cosmos, Polis and COOL.

Module:5	Estimation: Hardware	4	hours	

Hardware area, execution timing and power, **Case studies**

Module:6	Estimation: Software	4	hours	

Software memory and execution timing, Worst Case Execution Time, **Case studies**

Module:7	Co-simulation & Co-verification	7	hours	

Principles of Co-simulation – Abstract Level; Detailed Level – Co-simulation as Partitioning support – Co- simulation using Ptolemy approach, Virtual Prototyping, **Rapid Prototyping**.				
Module:8	**Contemporary issues**	**2**	**hours**	
	Total Lecture:	**45**	**hours**	

Text Books:

1. **Soonhoi Ha, Jürgen Teich, "Handbook of Hardware/Software Codesign", Springer , 2017**.

References:

1. Schaumont, Patrick, A," A Practical Introduction to Hardware/Software Codesign", 2013, reprint, Springer, India.
2. Felice Balarin, Massimiliano Chiodo, Paolo Giusto, Harry Hsieh, Attila Jurecska, Luciano Lavagno, Claudio Passerone, Alberto Sangiovanni-Vincentelli, Ellen Sentovich, Kei Suzuki, Bassam Tabbara, "Hardware-Software Co-Design of Embedded Systems: The POLIS Approach", Springer, 2012.
3. http://ptolemy.eecs.berkeley.edu/ptolemyII/ptII10.0/ptII10.0.1_20141217/ptolemy/domains/continuous/doc/index.htm

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Recommended by Board of Studies	12/09/2020		
Approved by Academic Council	No. 59th	Date	24/09/2020

Course Code	Course Title	L	T	P	J	C
ECE6049	MODERN AUTOMOTIVE ELECTRONICS SYSTEMS	2	0	0	4	3
Pre-requisite	Nil	Syllabus Version : 1				

Course Objectives:

The course is aimed at

[1] Instilling fundamental understanding of various automatic control systems and basic instrumentation involved in automobiles.

[2] Learning various automobile condition measurement and monitoring mechanisms.

[3] Acqutry with advanced electronic elements and their functional aspects in automobiles

Course Outcomes (CO):

At the end of the course the student will be able to

[1] Comprehend engine management system.

[2] Understand the various Ignition and Injection systems

[3] Explain the automotive control mechanisms.

[4] Learn the different monitoring systems for automobiles

[5] Understand the typical sensors for transportation.

[6] Acquire knowledge about upcoming trends in automotive electronics systems

[7] Use the knowledge attained and develop appropriate systems for societal issues

Module:1	Engine management systems	5 hours	

Introduction - components for engine management system - Open loop and closed loop control system – Engine cranking and warm up control –Acceleration, deceleration and idle speed control.

Module:2	Injection and ignition systems	5 hours	

Feedback carburetor system–Throttle body injection and multi point fuel injection system– Injection system controls –Advantage of electronic ignition systems–Types of solid state ignition systems and their principles of operation –Electronic spark timing control, Exhaust emission control engineering

Module:3	Automotive control mechanism	4 hours	

Electronic management of chassis systems, Vehicle motion control, anti – lock braking system, Tyre pressure monitoring system, Collision avoidance system, Traction control system.

Module:4	Automotive Electronics systems	4 hours	

Active suspension system Keyless entry system and Electronic power steering system, Electronic controls - lighting design - Horn – Warning systems – Brake actuation warning systems, Infotainment

Module:5	Monitoring of Automotive systems	4 hours	

Speed warning systems, oil pressure warning system, engine over heat warning system, air pressure warning system, safety devices-Wind shield wiper and washer, VANET

Module:6	Sensors for transportation - I	3 hours	

Basic sensor arrangement–Types of sensors, Oxygen Sensor –Cranking Sensor –Position Sensors

Module:7	Sensors for transportation - II	3 hours	

Engine cooling water temperature Sensor–Engine oil pressure Sensor–Fuel metering –Vehicle speed sensor and detonation sensor.

Module:8	Contemporary issues:	2 hours	

Total Lecture hours: 30 hrs

Text Book(s)

1. Tom Denton, Automobile Electrical and Electronic Systems, 2012, 4th Edition, Butter Worth Heinemann, United States

2. Bosch Automotive Electrics and Automotive Electronics, 2014, 5th Edition, Springer Vieweg, United States
3. Beckwith, T.G, Roy D.Marangoni, John H.Lienhard, Mechanical Measurements, 2011, 6th Edition, Addison Wesley, United States

Reference Books

1. Ernest O Doeblin, Measurement Systems, Application and design, 2013, 5th Edition McGraw Hill Book Co., United States
2. Holman, J.P, Experimental methods for Engineers, McGraw Hill Book Co., 2011, 8th Edition, United States
3. Robert Bosch Gmph, Automotive Hand Book, 2014, 9th Edition, Wiley, United States
4. William, B. Ribbens, Understanding Automotive Electronics, 2014, 8th Edition Butter Worth Heinemann, United States

Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.

Typical Projects

1. Design of Real Time Ignition Control System. Implement an automotive throttle control system using fuzzy logic approach and perform the controller synthesis in real time environment.

2. Develop a sliding mode controller to generate appropriate torque for the driving motor of electric vehicles that ensures optimality of the slip ratio for efficient vehicle brake.
3. Design a variable structure controller to deal with the strong nonlinearity of wheel slip in the design of ABS controller. Consider the several situations such as braking in dry road, wet road and snow road.

4. Develop a safety feature in cars to avoid colliding with a vehicle or an obstacle in the way. The main objective of the system is to help driver to prevent car collisions due to blind spots and their carelessness while driving.

5. Design a speed warning system (in-vehicle subsystem) that will monitor the vehicle speed and activate an auditory warning as well as record the violation when the pre-set speed limit is exceeded.

Recommended by Board of Studies : 27/02/2016

Approved by Academic Council : No: 40 Date : 18/03/2016

Course code	Course Title	L	T	P	J	C
ECE6073	AUTOSAR AND ISO STANDARDS FOR AUTOMOTIVE SYSTEMS	2	0	0	0	2
Pre-requisite	Nil	Syllabus version : 1				

Course Objectives: The course is aimed at:

1. Enabling the students to understand Autosar standards
2. Introducing to the students the basic knowledge of Communication Stack in Autosar
3. Preparing the students to understand the implementation and integration in Autosar

Expected Course Outcome:

At the end of the course, the student will be able to

1.Apply the knowledge of various autosar standards
2.Analyze autosar codes
3.Apply the AutoSAR – Implementation Integration
4.Analyze the AutoSAR – System Services
5. Implement CAN programming concepts through Autosar
6. Analyze the ISO/TS 16949 standards
7. Know the implementation aspects of ISO/TS 16949 standards

Module:1	**AutoSAR Standards**	3 hours	
General requirement on basic software modules – Functional, Fault operation and error detection.			
Module:2	**AutoSAR Standards – Communication Stack**	5 hours	
Network Management, TTCAN Interface standards, TTCAN Drivers			
Module:3	**AutoSAR – Implementation Integration**	3 hours	
Platform Types, Memory Mapping			
Module:4	**AutoSAR – System Services**	3 hours	
Watchdog Manager, Synchronized Time Base Manager			
Module:5	**ISO/TS 16949**	5 hours	
ISO/TS 16949 - ISO/TS 16949:2009 specifies the quality system requirements for the design and development, production, installation and servicing of automotive related products.			
Module:6	**Introduction to ISO26262 Standard: Basic Concepts**	3 hours	
Structure of ISO26262 standard and its parts-Vocabulary-Management of functional Safety-Concept Phase			
Module:7	**Introduction to ISO26262 Standard: Implementation Aspects**	**6 hours**	
Product Development System level-Product Development Hardware level-Product Development Software level-Production and Operation-Supporting Processes-ASIL Oriented and Safety Oriented Analysis-Guidelines on ISO26262 (Informative)-Case Studies to illustrate concepts, Hazard analysis and Risk assessment-Safety Goals, Preliminary Architecture-Functional Safety Concept			
Module:8	**Contemporary Topics**	**2 hours**	
	Total Lecture Hours:	**30 hours**	

Reference Books

1. Automotive Quality systems – David Hoyle, Butterworth Heinemann limited, 2000
2. www. autosar.org

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Mode of evaluation:			
Recommended by Board of Studies	12/09/2020		
Approved by Academic Council	No. 59	Date	24/09/2020

ECE6092	Intelligent IoT System Design and Architecture	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	Nil	Syllabus Version:				

Course Objectives:

1. To explore the characteristics of the Internet of things and its design.
2. To enable the students to get familiar with IoT architecture models.
3. To acquaint the students with various security concepts and data analytics in the IoT system.
4. To develop and deploy an IoT enabled prototypes for real-life use cases.

Expected Outcomes:

Upon completion of this course, the student will be able to

1. Assimilate the technologies that enable IoT and to interpret the different components in IoT architecture.
2. Comprehend the concepts of edge computing and edge enabled solutions for real-time industrial applications.
3. Envision the IoT communication architecture models and the protocol stack for the cost-effective design of IoT applications on different platforms.
4. Interpret the security threats and to design a resilient IoT Architecture.
5. Perceive the data analytics tools and gain knowledge to devise an intelligent IoT system.
6. Analyze cloud platform services to perform IoT data analytics and make the system intelligent.
7. Design and develop smart IoT prototypes for use cases under discussion.

Module:1	IoT Essentials	4	hours		

Evolution of IoT, IoT characteristics, IoT enabling technologies, Planning for an IoT solution, IoT use case development - Need and goals, IoT Architecture reference model, Functional blocks of IoT- Communication and security Model, Service oriented architecture, Event-driven architecture, Applications and standards.

Module:2	Edge Computing	5	hours		

Introduction to Edge/Fog computing, Edge nodes and gateway, Node to edge interfaces, Protocol and standards for edge devices, IoT edge architecture, IoT supported hardware- Raspberry pi, ARM Cortex Processors, Software Platforms for IoT Edge - Raspbian Pi OS, RIOT, Python packages for edge computing, Edge security, Real time applications of edge computing.

Module:3	IoT Communication Architecture and Protocols	5	hours		

Communication models for IoT, 6LoWPAN, IPv4/IPv6, IoT communication protocols - MQTT, CoAP, LoRaWAN, RTLS, RPL, Communication API's.

Module:4	IoT Security and Privacy	4	hours		

IoT risks and security challenges, IoT security architecture - A trust model, Restricting network access through security groups- Specific user access control, Data confidentiality and availability, User Authentication/Authorization methods, Block chain for IoT security and privacy.

Module:5	**Smart Data Analytics**	**4**	**hours**		
Need for data analytics, Data generation, Data pre-processing, Handling imbalanced data sets, Missing values, Outliers, Intelligent IoT systems –Supervised and Unsupervised machine learning algorithms, Deep learning for IoT- Predictive analytics, Python functions and modules for data analytics, Big Data analytics and frameworks.					
Module:6	**Data Analytics in Cloud**	**4**	**hours**		
Layered cloud architecture for data analytics, Elasticity in cloud for data warehousing, Virtualization for Data-center automation, Real-time cloud data analytics tools, AI Services-Data based decisions, Cloud data lake, Exploratory data analysis, Open source cloud platforms and services.					
Module: 7	**IoT Architecture for specific use cases**	**2**	**hours**		
Roadmap for complete IoT solution, Open source IoT platforms, IoT solution to Health care, Automotive applications, Smart IoT architecture for Retail, Logistics and Farming, Intelligent IoT architecture for Home automation, Industry applications, Smart city and other applications to cater the societal requirements.					
Module:8	**Contemporary Issues**	**2**	**hours**		
	Total Lecture:	**30**	**hours**		
Text Books:					
1. Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015. 2. John R. Vacca, “Cloud Computing Security: Foundations and Challenges”, CRC Press, 2016. 3. Dey, Hassanien, Bhatt, Ashour and Satapathy “Internet of Things and Big Data Analytics towards Next-Generation Intelligence”, Springer, 2018.					
Reference Books:					
1. Adrian McEwen & Hakim Cassimally, “Designing the Internet of Things”, Wiley, 2013. 2. Ovidiu Vermesan, Peter Friess, “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers, 2013. 3. Olivier Hersent, David Boswarthick, Omar Elloumi, “The Internet of Things – Key applications and Protocols”, Wiley Publication, 2012. 4. Nick Antonopoulos, Lee Gillam, “Cloud Computing: Principles, Systems and Applications”, Springer, 2010. 5. Hwaiyu Geng, “Internet of Things and Data Analytics Handbook”, Wiley Publishers, 2017. 6. Rajkumar Buyya and Satish Narayana Srirama, “Fog and Edge Computing: Principles and Paradigms”, Wiley series, 2019.					
Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment and Final Assessment Test.					
Typical Projects:					

1. Voice controlled home automation and security.
2. Vehicle tracking system.
3. Social network data analytics.
4. Secured edge computing with any major cloud platform.
5. Remote monitoring and sensing in agriculture.
6. Automatic parking system.
7. Smart retail management.
8. Predictive analytics in health care.
9. Warehousing and logistics system.
10. Water flow monitoring and management.

Mode of Evaluation: Project Reviews I,II and III			
Recommended by Board of Studies		12/09/2020	
Approved by Academic Council	No. 59th	Date	24/09/2020

Course Code	Course Title	L	T	P	J	C
ECE 6093	Advanced Machine Leaning and Deep Learning	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version : 1.0				

Course Objectives:

The course is aimed at

[1] Understanding about the fundamentals of machine learning and neural networks

[2] Enabling the students to acquire knowledge about pattern recognition.

[3] Motivating the students to apply deep learning algorithms for solving real life problems.

Course Outcomes (CO):

At the end of the course the student will be able to

[1] Comprehend the categorization of machine learning algorithms.

[2] Understand the types of neural network architectures, activation functions

[3] Acquaint with the pattern association using neural networks

[4] Explore various terminologies related with pattern recognition

[5] Adopt different feature selection and classification techniques

[6] Understand the architectures of convolutional neural networks

[7] Comprehend advanced neural network architectures such as RNN, Autoencoders, and GANs.

Module:1	Learning Problems and Algorithms	4 hours	

Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms

Module:2	Neural Network – I	6 hours	

Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation

Module:3	Neural Network – II	6 hours	

Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, Auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning

Module:4	**Machine Learning: Terminologies**	**7 hours**	
Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance			
Module:5	**Machine Learning: Feature Selection and Classification**	**6 hours**	
Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.			
Module:6	**Convolutional Neural Networks**	**7 hours**	
Feed forward networks, Activation functions, backpropagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.			
Module:7	**RNNs, Autoencoders and GANs**	**7 hours**	
State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Autoencoders: Convolutional Autoencoders, Denoising autoencoders, Variational autoencoders, GANs: The discriminator, generator, DCGANs			
Module:8	**Contemporary issues:**	**2 hours**	
		Total Lecture hours: 45 hrs	

Text Book(s)

3. J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learning
4. Deep Learning, Ian Good fellow, Yoshua Bengio and Aaron Courville, MIT Press, ISBN: 9780262035613, 2016.

Reference Books

6. The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009.
7. Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006.
8. Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.

Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.

Recommended by Board of Studies : 12/09/2020

Approved by Academic Council : 59th Date : 24/09/2020

Course code	**Scripting Languages For Design Automation**	**L**	**T**	**P**	**J**	**C**

ECE 6094			2 0 2 0 3
Pre-requisite	**ECE5043 Embedded Programming**		**Syllabus version**
			v. 1.0

Course Objectives :

The course is aimed to motivate the students to

1. Work in LINUX environment.
2. Develop the PERL scripts
3. Develop the TCL & TK scripts for automation
4. Develop the python scripts for automation

Expected Course Outcome :

At the end of the course the students will be able to

1. Comprehend PERL Concepts and its range of applications to which they are suited
2. Develop skills and understanding PERL
3. Understanding the basics of TCL scripts
4. Comprehend the concept of Tk
5. Get introduced to Python Programming
6. Develop programming skills on python functions
7. Understanding the OOP and exception Handling using python
8. Expertise in Scripting language

Module:1	**PERL**	**4 hours**	
History and Concepts of PERL - Scalar Data - Arrays and List Data - Control structures – Hashes - Basics I/O - Regular Expressions – Functions - Miscellaneous control structures - Formats.			
Module:2	**Advanced Topics in PERL**	**4 hours**	
Directory access - File and Directory manipulation - Process Management - Packages and Modules.			
Module:3	**TCL**	**4 hours**	
An Overview of TCL and TK -TCL Language syntax – Variables – Expressions – Lists - Control flow – procedures - Errors and exceptions - String manipulations.			
Module:4	**Advanced Topics in TCL**	**4 hours**	
Accessing files- Processes. Applications - Controlling Tools - Basics of TK.			
Module:5	**Python**	**4 hours**	
Introduction to Python, Objects: strings, lists, dictionary, tuple, files, Looping constructs			
Module:6	**Python: Functions and Modules**	**4 hours**	
Functions: basics, scope, arguments, Modules: packages (internal and external), decorators			
Module:7	**Python: OOP and Exception Handling**	**4 hours**	
OOP: classes, operator overloading, designing with classes, Exceptions: exception objects, designing with exceptions, Meta-classes			
Module:8	**Contemporary issues:**	**2 hours**	
	Total Lecture hours:	**30 hours**	

Reference Books	
1.	Guido van Rossum Fred L. Drake, Jr., editor, “Python Tutorial Release 3.2.3”, 2012.
2.	Larry Wall, Tom Christiansen, John Orwant, “Programming PERL”, Oreilly Publications, Fourth Edition, 2012.
3.	John K. Ousterhout, Ken Jones, “TCL and the TK Toolkit”, Pearson Education, Second Edition, 2010.
4.	Eric Matthes, “Python Crash Course: A Hands-on, Project-based Introduction to Programming”, Second Edition, No starch press, 2019

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	PERL: • Write a script that computes the average of each column in a table of data • Write a script extracts a subset of docs from a database • Write a script does "string replacement" on the standard input	8 hours
2.	TCL/TK: • Develop a clock that shows time either analog or digital • Develop a small calculator in Tcl/Tk. In addition to the buttons on screen, use any of expr's other functionalities via keyboard input. • Write a script that allows doodling (drawing with the mouse)	8 hours
3.	Python: • Python Implementation of Mutual-Exclusion (MUTEX algorithm) for Embedded operating systems • Python Implementation of Round Robin Scheduling for Embedded OS	8 hours
4.	Verification automation tool development using Perl/Python scripts	6 hours
Total Laboratory Hours		30 hours

Mode of evaluation: Continuous Lab Assessment			
Recommended by Board of Studies	12/09/2020		
Approved by Academic Council	No. 59th	Date	24/09/2020

Course Code	Course Title	L	T	P	J	C
CSE6052	PARALLEL PROCESSING AND COMPUTING	3	0	0	0	3
Pre-requisite	Nil	Syllabus Version : 1				
Course Objectives:						

The course is aimed at

[1] Teaching the students to understand the scope, design and model of parallelism and to know the parallel computing architecture

[2]Teaching students to do analytical modelling and performance of parallel programs

[3]Teaching students to solve a complex problem with message passing model

[4] Programming with CUDA and analyse complex problems with shared memory programming

Course Outcomes (CO):

At the end of the course the student will be able to

[1] Understand the fundamentals of parallel processing

[2] Illustrate the scheduling loops and process execution

[3] Realize the parallel system architecture with CUDA

[4] Comprehend the kernel based parallel programming concepts

[5] Apply the performance consideration for parallel processing

[6] Analyse various parallel computation patterns

[7] Perform spare matrix vector multiplications

Module:1	**Introduction to Parallel Processing**	**5 hours**	
Parallel processing – Concepts and Terminology- Parallel Computer Memory Architectures - Parallel Programming Models - Designing Parallel Programs- Performance Analysis			
Module:2	**Shared Memory Programming**	**6 hours**	
Processes and Threads - Scope of Variables – Reduction Clause – Directives – Scheduling Loops – Caches, Cache coherence and False Sharing – Thread Safety – Examples: Bubble-sort, Odd- even transposition sort			
Module:3	**Parallel Computing**	**6 hours**	
Portability and Scalability- Introduction to CUDA, Data Parallelism and Threads-Memory Allocation and Data Movement API- Kernel-Based SPMD Parallel Programming-Kernel based Parallel Programming, Multidimensional Kernel Configuration- Basic Matrix-Matrix Multiplication			
Module:4	**Kernel-Based Parallel Programming**	**6 hours**	
Thread Scheduling-Control Divergence- Memory Model and Locality - CUDA Memories-Tiled Parallel Algorithms- Tiled Matrix Multiplication- Tiled Matrix Multiplication Kernel-Handling Boundary Conditions in Tiling-- A Tiled Kernel for Arbitrary Matrix Dimensions			
Module:5	**Performance Considerations**	**6 hours**	
Warps and Thread execution - Global Memory Bandwidth - DRAM Bandwidth - Memory Coalescing -Dynamic partition of execution resources			
Module:6	**Parallel Computation Patterns**	**8 hours**	
Convolution- Tiled Convolution- 2D Tiled Convolution Kernel- Data Reuse in Tiled Convolution-Reduction- A Basic Reduction Kernel- Scan (Prefix Sum) - A Work-Inefficient Scan Kernel- A Work-Efficient Parallel Scan Kernel			
Module:7	**Sparse Matrix Vector Multiplication**	**6 hours**	
Parallel SpMV Using CSR-Padding and Transposition-Using Hybrid to Control Padding-Sorting and Partitioning for Regularization			
Module:8	**Contemporary issues:**	**2 hours**	
			Total Lecture hours: 45 hrs

Text Book(s)

1. Ananta Grama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing, 2011, Second Edition, Addison Wesley Professional, UK.
2. David B. Kirk and Wen-mei W. Hwu, Programming Massively Parallel Processors: A Hands-on Approach, 2016, Third Edition, Morgan Kaufmann Publishers, US.

Reference Books 1. Pacheco, Peter. An Introduction to Parallel programming, 2011, First Edition, Morgan Kaufmann Publishers, USA
Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.
Recommended by Board of Studies : 27/02/2016
Approved by Academic Council : No. 40 Date : 18/03/2016