VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF ELECTRICAL ENGINEERING

M. Tech Control and Automation

(M.Tech C&A)

Curriculum

(2021 - 2022 Admitted Students)

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 and critical 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 and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF ELECTRICAL ENGINEERING

To be a leader for academic excellence in the field of electrical, instrumentation and control engineering imparting high quality education and research leading to global competence for the societal and industrial developments.

MISSION STATEMENT OF THE SCHOOL OF ELECTRICAL ENGINEERING

- Impart high quality education and interdisciplinary research by providing conducive teaching learning environment and team spirit resulting in innovation and product development.
- Enhance the core competency of the students to cater to the needs of the industries and society by providing solutions in the field of electrical, electronics, instrumentation and automation engineering.
- Develop analytical skills, leadership quality and team spirit through balanced curriculum.

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

M. Tech Control and Automation

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies in engineering or management.

6. Graduates will pursue career paths in teaching or research.

M. Tech Control and Automation

PROGRAMME OUTCOMES (POs)

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

PO_03: Having an ability to design and conduct experiments, as well as to analyze and interpret data

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

PO_05: Having problem solving ability- solving social issues and engineering problems

PO_06: Having adaptive thinking and adaptability

PO_07: Having a clear understanding of professional and ethical responsibility

PO_08: Having a good cognitive load management [discriminate and filter the available data] skills

M. Tech Control and Automation

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Control and Automation) programme, graduates will be able to

- PSO1: Apply technical knowledge, skills and analytical ability to design and develop controllers as well as employ techniques for automation of systems using modern tools and technologies.

- PSO2: Analyse, interpret and solve problems related to process control, automation, measurement and control etc.

- PSO3: Solve research gaps and provide solutions to socio-economic, and environmental problems.

VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

M. Tech Control and Automation

CREDIT STRUCTURE

Category-wise Credit distribution

Credits Breakup	
	CREDITS
University Core	27
University Elective	6
Program Core	19
Program Elective	18
Total	70

M. Tech Control and Automation

DETAILED CURRICULUM

University Core

S. No.	Course Code	Course Title	L	T	P	J	C
1.	MAT6001	Advanced Statistical Methods	1	0	2	0	2
2.	ENG5001	Fundamentals of Communications of Skills	0	0	2	0	1
3.	ENG 5002	Professional and Communication Skills	0	0	2	0	1
4.	STS5001	Essentials of Business Etiquettes	3	-	-	-	1
5.	STS5002	Preparing for Industry	3	-	-	-	1
6.	SET5001	Science, Engineering and Technology Project - I	-	-	-	8	2
7.	SET5002	Science, Engineering and Technology Project - II	-	-	-	8	2
8.	EEE 6099	Master's Thesis	-	-	-	64	16
9.	GER5001/ FRE5001	Deutsch Fuer Anfaenger/ Francais Fonctionnel	2	0	0	0	2

Programme Core

S. No.	Course Code	Course Title	L	T	P	J	C
1.	EEE5012	System Theory	2	0	2	0	3
2.	EEE5013	Random variables and State estimation	3	0	0	0	3
3.	EEE5014	Smart Sensor Systems	3	0	0	0	3
4.	EEE5015	Process Dynamics and Control	3	0	2	0	4
5.	EEE5016	Real Time Embedded Systems	2	0	0	4	3
6.	EEE5017	Industrial Automation	2	0	2	0	3

M. Tech Control and Automation

Programme Elective

S. No.	Course Code	Course Title	L	T	P	J	C
1.	EEE5018	Industrial Robotics	3	0	0	0	3
2.	EEE5019	Control of Electric Drives	3	0	0	0	3
3.	EEE5020	Machine Learning	2	0	0	4	3
4.	EEE5021	Industrial Data Networks	3	0	0	0	3
5.	EEE5022	Power Plant control & Instrumentation	2	0	0	4	3
6.	EEE5029	Data Acquisition & Hardware Interfaces	3	0	0	0	3
7.	EEE5030	Flight Control Systems	3	0	0	0	3
8.	EEE5031	Advanced Reliability Engineering	1	2	0	0	2
9.	EEE5032	Building Automation	3	0	0	0	3
10.	EEE6011	Optimal Control Systems	3	0	0	0	3
11.	EEE6012	Adaptive and Robust Control	2	0	0	4	3
12.	EEE6013	Discrete Control Systems	3	0	0	0	3
13.	EEE6014	Fault detection and diagnosis	2	0	0	4	3
14.	EEE6015	SCADA Systems and Applications	3	0	0	0	3
15.	EEE6016	Modelling and Simulation of Electrical Systems	2	0	0	4	3
16.	EEE6021	Multivariable Control System	3	0	0	0	3

MAT6001	Advanced Statistical Methods	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	NIL	Syllabus Version				
		v.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	**46th AC**	Date	**24-08-2017**

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

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	**46th**	Date	**24-8-2017**

ENG5002	Professional and Communication Skills	L	T	P	J	C
		0	0	2	0	1
Pre-requisite	**ENG5001**	**Syllabus version**				
		v.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	**47th**	Date	**05-10-2017**

STS5001	Essentials of Business Etiquettes	L	T	P	J	C
		3	0	0	0	1
Pre-requisite	NIL	Syllabus version				
		v.3.0				

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:

1. Enabling students to use relevant aptitude and appropriate language to express themselves
2. 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			
Approved by Academic Council	**53rd**	Date	**13/12/2018**

STS5002	Preparing for Industry	L	T	P	J	C
		3	0	0	0	1
Pre-requisite	**NIL**	**Syllabus version**				
		v.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:

1. 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	**45th AC**	Date	**15/06/2017**

EEE**6099**	**Masters Thesis**	**L**	**T**	**P**	**J**	**C**
		0	**0**	**0**	**0**	**16**
Pre-requisite	**As per the academic regulations**	**Syllabus version**				
		v.1.0				

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation

Expected Course Outcome:

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

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing
5. Synthesise the results and arrive at scientific conclusions / products / solution
6. Document the results in the form of technical report / presentation

Contents

1. Capstone Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Project can be for two semesters based on the completion of required number of credits as per the academic regulations.
3. Should be individual work.
4. Carried out inside or outside the university, in any relevant industry or research institution.
5. Publications in the peer reviewed journals / International Conferences will be an added advantage

Mode of Evaluation**:** Periodic reviews, Presentation, Final oral viva, Poster submission

Recommended by Board of Studies	**10/06/2016**		
Approved by Academic Council	**41st**	Date	**17/06/2016**

GER5001	Deutsch Fuer Anfaenger	L	T	P	J	C
		2	0	0	0	2
Pre-requisite	**NIL**	**Syllabus version**				
		v.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: a) Gespräche mit Familienmitgliedern, Am Bahnhof, b) Gespräche beim Einkaufen ; in einem Supermarkt ; in einer Buchhandlung ; c) 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	**10/06/2016**		
Approved by Academic Council	**41th**	Date	**17/06/2016**

FRE5001	Francais Fonctionnel	L	T	P	J	C
		2	0	0	0	2
Pre-requisite	**NIL**	**Syllabus version**				
		v.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: d) Réserver un billet de train e) Entre deux amis qui se rencontrent au café f) Parmi les membres de la famille g) 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	**10/06/2016**		
Approved by Academic Council	**41th**	Date	**17/06/2016**

EEE5012	System Theory	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

To present a clear exposition of basics of modern control including,

1. State variable representation of dynamic systems
2. Solution of the state equation
3. Stability, controllability and observability of systems

Expected Course Outcome:

On completion of the course, the student will be able to

1. Represent dynamical systems in various state space formats
2. Solve linear and nonlinear state equations
3. Analyze the properties of linear systems such as controllability and observability
4. Design state feedback controller and state observers for simple practical dynamic systems.
5. Perform equilibrium point analysis for linear and nonlinear systems.
6. Utilize the techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion to assess the stability of certain class of non-linear system.
7. Realize reduced and minimal system equations.
8. Design and conduct experiments, as well as analyze and interpret data

Module:1	**State Variable Representation:**	**4 hours**

Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity-Non uniqueness of state model-State Diagrams-Physical System and State Assignment

Module:2	**Solution of State Equation:**	**4 hours**

Existence and uniqueness of solutions to continuous-time state equations-Solution of linear time varying and linear time invariant state equations-Evaluation of matrix exponential- System modes-Role of Eigenvalues and Eigenvectors.

Module:3	**Controllability and Observability:**	**4 hours**

Controllability and Observability - Stabilizability and Detectability-Test for Continuous time systems- Time varying and Time invariant case.

Module:4	**Modal Control :**	**4 hours**

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

Module:5	**Lyapunov Stability:**	**4 hours**

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems.

Module:6	**Lyapunov's Direct Method**:	**4 hours**

The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and

Variable-Gradient Method.			
Module:7	**Realization:**		**4 hours**
Output Controllability-Reducibility- System Realizations minimal realization, balanced realization			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	Ogata, "Modern Control Engineering", 5th Edition, Prentice Hall India, 2010.
2.	M. Gopal, "Modern Control System Theory", 3rd edition, New Age International, 2014.
Reference Books	
1.	Slotine and Li, "Applied Nonlinear Control", Prentice Hall Inc., 2005.
2.	Hassan K Khalil, "Nonlinear Control", Pearson, Boston, 2015.
Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
1.	State modeling of armature controlled motor	2 hours
2.	State modeling of field controlled motor	2 hours
3.	State modeling of dc generator	2 hours
4.	State modeling of balancing broomstick	2 hours
5.	State modeling of bridge circuit	2 hours
6.	State modeling of magnetic suspension system	2 hours
7.	State modeling of ball on beam system	2 hours
8.	Controllability and observability of armature controlled dc motor	2 hours
9.	Controllability and observability of balancing broomstick	2 hours
10.	Controllability and observability of bridge circuits	2 hours
11.	Controllability and observability of magnetic suspension system	2 hours
12.	Design of state feedback controller for balancing broomstick problem	2 hours
13.	Design of observer for balancing broomstick problem	2 hours
14.	Design of state feedback controlled, balancing broomstick problem with observer	2 hours
15.	Stability analysis of straight and inverted pendulum	2 hours
	Total Laboratory Hours	**30 hours**
Mode of Evaluation**:** Assignment / FAT		

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5013	Random Variables and State Estimation	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To provide information on identifying and controlling processes with random behavior

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Define, understand and manipulate scalar and multiple random variables, using the theory of probability.
2. Understand the relationship between random variables within a random vector
3. Design maximum likelihood estimators and MMSE estimators.
4. Solve basic problems in filtering, prediction and smoothing.
5. Design Kalman filter for prediction and control of stochastic systems.
6. Conduct experiments to estimate nonparametric system models
7. Choose, design and test a structure for parametric estimation.

Module:1	**Basics of Probability Theory:**	**5 hours**
Review, Random variables, Multiple random variables		
Module:2	**Random Process and their characteristics:**	**5 hours**
Correlation functions: autocorrelation, cross correlation. Temporal and Spatial Characteristics		
Module:3	**Parameter Estimation Theory:**	**8 hours**
Principle of estimation, properties, Unbiased and consistent estimators, Cramer-Rao bounds. Maximum Likelihood estimators, Bayesian estimation: MAP, MSE, MMSE. Waveform estimation.		
Module:4	**Wiener Estimation:**	**5 hours**
Wiener Hoff Equation, FIR Wiener filter, Causal IIR Wiener filter, Non-causal IIR Wiener filter. Application of Weiner's theory in compensator design for feedback control system.		
Module:5	**Markov & Kalman Estimator's:**	**8 hours**
Gauss Markov model for vector random process, Kalman Filtering and Prediction for discrete and continuous time system, Minimum variance control.		
Module:6	**Nonparametric Model Estimation**:	**6 hours**
Correlation and spectral analysis for non-parametric model identification, obtaining estimates of the plant impulse, step and frequency responses from identification data.		
Module:7	**Parametric Model Estimation**:	**6 hours**
Prediction Error Model Structures, parametric estimation using one-step ahead prediction error model structures and estimation techniques for ARX, ARMAX, Box-Jenkins, FIR, Output Error models. Residual analysis for determining adequacy of the estimated models.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 Hours**

Text Book(s)	
1.	H Stark and J Woods, Probability, Statistics and Random Processes for Engineers, 4th edition, Prentice Hall, 2012.
2.	Arun K. Tangirala, Principles of System Identification: Theory and Practice, Taylor and Francis, 1st Edition, 2014.
Reference Books	
1.	Alberto Leon-Garcia, Probability, Statistics and Random Processes for Electrical Engineering, 2nd Edition, Pearson Education, 2016.
2.	H. L. Vantrees, K. L. Bell and Z. Tian, Detection, Estimation and Modulation theory, 2nd Edition, Wiley, 2013.
3.	R. G. Brown, and Patrick Y. C. Hwang. Introduction to Random Signals and Applied Kalman Filtering with Matlab Exercises, 4th Edition Wiley, 2012.
4.	A. Papoulis and S. U. Pillai, Probability, Random Variables and Stochastic Processes, 4th Edition, McGraw-Hill, 2014 (reprint).

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

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5014	Smart Sensor Systems	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**				**Syllabus version**	
Anti-requisite	NIL				v. 1.1	

Course Objectives:

1. To impart knowledge on Smart sensing technology and its applications.
2. To introduce the standards and protocols used for smart sensing.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Select the right sensor for a given application.
2. Design basic building blocks for a Smart sensor.
3. Design compensators and perform calibration for smart sensors.
4. Design, synthesize and layout a VLSI sensor.
5. Design micro power generation systems
6. Interpret IoT based systems for smart applications.
7. Apply smart sensors for Health, Industrial and Home related application.

Module:1	**Smart Sensor Introduction:**	**6 hours**

Classic vs Smart sensors, Architecture of Smart Sensors: Important components, their features. Monolithic integrated smart sensor, Hybrid integrated smart sensor, Impedance sensing system, Smart temperature sensor, Smart Wind sensor, Smart Hall sensor.

Module:2	**Linearization:**	**7 hours**

Linearization using shunt resistance, Divider circuit, higher order linearizing circuit. Linear interpolation, Piecewise linearization, Lookup table approach, Adaptive filters based approach.

Module:3	**Calibration and Compensation:**	**6 hours**

Calibration and Self Calibration of smart sensors, Offset compensation, Error and Drift compensation, Lead wire compensation, Temperature effect and compensation.

Module:4	**VLSI Sensors:**	**6 hours**

Analog Numerical computation - CORDIC Computation. Adaptive filtering – LMS algorithm, Bit stream multiplication. Analog VLSI based Neural Network.

Module:5	**Micro-power Generation:**	**6 hours**

Introduction, Energy storage system, Thermoelectric energy harvesting, Vibration and Motion energy harvesting, Far-Field RF energy harvesting, Photovoltaic.

Module:6	**Standards and protocols:**	**7 hours**

Design and Implementation of IoT for Environmental Condition Monitoring, Development of Smart Bed for Health Care Application, Study of Smart City and its Design, Wearable smart sensors, Biosensors and applications.

Module:7	**Case Studies:**	**5 hours**

Design and Implementation of IoT for Environmental Condition Monitoring, Development of Smart Bed for Health Care Application, Study of Smart City and its Design, Wearable smart sensors, Biosensors and applications.			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**45 hours**	
Text Book(s)			
1.	Manabendra Bhuyan, "Intelligent Instrumentation: Principles and Applications", CRC Press, 2011.		
2.	Gerard Meijer, Kofi Makinwa, Michiel Pertijs, "Smart Sensor Systems: Emerging Technologies and Applications", IEEE press, Wiley, 2014.		
Reference Books			
1.	Kevin Yallup, Krzysztof Iniewski, "Technologies for Smart Sensors and Sensor Fusion", CRC Press, 2014.		
2.	Krzysztof Iniewski, "Smart Sensors for Industrial Applications", CRC Press, 2013.		
Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE5015	Process Dynamics and control	L	T	P	J	C
		3	0	2	0	4
Pre-requisite	**NIL**					**Syllabus version**
Anti-requisite	NIL					v. 1.1

Course Objectives:

1. To provide in depth knowledge of process modeling
2. To understand the dynamic and static behavior of the modeled system.
3. To Select of Control Valve for different applications.
4. To design PID and Advanced control strategies based on process model.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Develop mathematical models for dynamic processes
2. Analyze process stability, dynamic responses, frequency analysis of dynamic processes.
3. Choose necessary final control element for a given application.
4. Select and tune PID controllers for the given systems.
5. Analyze the performance of a closed loop control approach.
6. Plan a control strategy for a process involving multiple variables and constraints.
7. Design controller strategies involving models of the systems.
8. Design and Conduct experiments, as well as analyze and interpret data

Module:1	**Process Dynamics:**	**7 hours**

Need for Process Control - objective of modelling-models of hydraulic, liquid, thermal and gas systems - Degrees of Freedom - Continuous and batch processes – Self regulation – Lumped and Distributed parameter models – Linearization of nonlinear systems.

Module:2	**Dynamic and Steady State Behavior of Process:**	**4 hours**

Dynamic response of a first order process, first order plus dead time process, second order process, pure capacitive process, pure dead time, higher order process; inverse response; Pade approximation.

Module:3	**Final Control Elements:**	**6 hours**

I/P converter - Pneumatic and electric actuators – Valve Positioner – Control Valves – Characteristic of Control Valves - Inherent and Installed characteristics – Modeling of pneumatic control valve – Valve body - Commercial valve bodies – Control valve sizing – Cavitation and flashing – Selection criteria.

Module:4	**Control Actions:**	**7 hours**

Concept of servo and regulatory problems - Selection of measured, manipulated and controlled variables - Types of controller - Characteristic of on-off, proportional, integral and derivative controllers – P+I,P+D and P+I+D control modes – Auto/manual transfer - Reset windup – Practical forms of PID Controller.

Module:5	**Design of feedback controller:**	**6 hours**

Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio – Tuning – Process reaction curve method, Continuous cycling method - direct synthesis

Module:6	**Enhancement to single loop regulatory control:**	**7hours**
Feed forward controller: design with steady state model, design with dynamic model, combination of feed forward-feedback structure - Cascade control: analysis and design - Ratio control - split range control - override control - inferential control.		
Module:7	**Model based control:**	**6 hours**
IMC structure – development and design - IMC based PID control – MPC: Dynamic matric control, Generalized predictive control.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Seborg, Dale E., Duncan A. Mellichamp, Thomas F. Edgar, and Francis J. Doyle, "Process dynamics and control", 4th edition, John Wiley & Sons, 2016.
2.	Stephanopoulos, George, "Chemical Process Control: An Introduction to Theory and Practice"**,** Pearson India Education Services, 2015

Reference Books

1.	Coughanowr, Donald R., and Lowell B. Koppel, "Process systems analysis and control", McGraw-Hill, 2009.
2.	Johnson, Curtis D, "Process control instrumentation technology", Prentice Hall, 2013.
3.	Lipták, Béla G., ed. "Process Control: Instrument Engineers' Handbook. Butterworth-Heinemann, 2013.
4.	Bequette, B.W., "Process Control Modeling, Design and Simulation", Prentice Hall of India, 2010.

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

List of Challenging Experiments (Indicative)

1.	Interacting and Non-interacting System a) Time Constant b) Response	2 hours
2.	Level Control Loop a) Servo & Regulatory Problem b) Level Transmitter Characteristics c) FCE Characteristics	2 hours
3.	Pressure Control Loop a) Servo & Regulatory Problem b) Modeling of Pressure Process Station	2 hours
4.	Flow Control Loop a) Servo & Regulatory Problem b) Tuning of controller using Auto tuning method	2 hours
5.	P, ON-OFF Control of Thermal Process	2 hours

6.	I/P & P/I Converter a) Linearity b) Hysteresis c) Deviation	2 hours
7.	Control Valve characteristics a) Verifying the inherent and installed characteristics of control valve b) Rangeability of control valve	2 hours
8.	Control of Cascade Process	2 hours
9.	Performance comparison different controller tuning methods	2 hours
10.	Dead time compensation using smith predictor	2 hours
11.	Disturbance rejection assessment of IMC-PI controller	2 hours
12.	Simulation of Nonlinear process models using ODE solver	2 hours
13.	Position and velocity algorithm realization using MATLAB	2 hours
14.	Design and verification of Feed Forward controller	2 hours
15	Performance comparison of single and Multi-loop controllers	2 hours
	Total Laboratory Hours	**30 hours**

Mode of Evaluation**:** Assignments / FAT			
Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE5016	Real Time Embedded Systems	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To give an emphasis hardware architecture and network interfaces of embedded system.
2. To provide essential knowledge on various wireless technologies in the design of embedded system.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Adapt with the trends in embedded system development.
2. Design hardware components for embedded system applications.
3. Develop and test programs for embedded system applications.
4. Design and develop embedded system for multifarious applications.
5. Develop real time OS architectures and functions.
6. Develop and test Finite State Machine models.
7. Design systems by implementing state and state transition diagrams
8. Design a component or a product applying all the relevant standards with realistic Constraints.

Module:1	**Overview of Embedded system and Software:**	**3 hours**

Embedded system- Definition, Categories, Requirements. Challenges and issues in embedded software development, Trends in embedded software development, Applications of embedded systems.

Module:2	**Hardware Architecture of Embedded System:**	**4 hours**

Processor, Memory, Memory models, Latches and Buffers, crystal, Timers, reset circuit, Watchdog timer, chip select logic circuit, ADC and DAC, Display units, Communication interfaces, Introduction to emulators.

Module:3	**Programming Embedded Systems:**	**4 hours**

Program Design - Design Patterns for Embedded Systems - Programming Languages - Object Oriented Programming - Use of High Level Languages - Compiling, Assembling, Linking, Debugging - Program Validation and Testing.

Module:4	**Embedded System Development:**	**4 hours**

Design Methodologies - Requirement Analysis - Static Modeling - Object and Class Structuring - Dynamic Modeling - Architectural Design - Hardware-Software Partitioning - Hardware-Software Integration -Fault-tolerance Techniques -Reliability Evaluation Techniques.

Module:5	**Real Time Operating System :**	**6 hours**

OS Dependent functionalities – Resource management – RTOS vs General purpose OS. Kernel Architecture and Functionalities (Task management, Process Scheduling, Resource management (Semaphores and Mutex), Task Synchronization. Embedded software development Life cycle. Structure of C compiler, code optimization.

Module:6	**Moore and Mealy Models:**	**3 hours**

Moore and Mealy FSM- Block diagram, definition of the state, building state transition diagram to state table, Relative trade-offs. Finite State Machine (FSM) - Rules for designing FSM

Module:7	**Embedded System Modeling:**	**4 hours**
Design of a Level to Pulse converter, Design examples implementing state and state transition diagram for vending machine, ATM, digital watch interface. Introduction to CPLD and FPGA.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Wayne Wolf, "Computers as Components- Principles of Embedded Computer Systems Design", Morgan Kaufman publishers, 3rd Edition, 2012.
2.	David.E.Simon, "An Embedded Software primer", Pearson Education Inc., 2012.
Reference Books	
1.	Tammy Noergaard,"Embedded Systems Architecture A Comprehensive Guide for Engineers and Programmers", Oxford, Newnes: Elsevier, 2013
2.	Frank Vahid, Tony Givagis, "Embedded System Design: : a unified hardware / software introduction", Wiley, 2010
3.	C.M. Krishna, Kang G. Shin, "Real Time systems", McGraw Hill, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**05/03/2015**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5017	Industrial Automation	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. Provide strong foundation to solve control and instrumentation problems in continuous or batch problems.
2. Technical competence through hands-on experience with industrial hardware and software.
3. Systematic design approach to engineering projects through solving tutorial problems and completing the major assignment.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Select and interface hardware for an automatic control system.
2. Use PLC for an automatic control system confining to standards.
3. Develop PLC code for automation applications requiring special functions.
4. Test digital and analog data in PLC based applications.
5. Design or configure various subsystems for industrial automation.
6. Plan the hardware and software component required to constitute a SCADA system.
7. Develop code and configure DCS to handle local and distributed automation tasks
8. Design and conduct experiments, as well as analyze and interpret data

Module:1	**Introduction to Programmable Logic Controllers:**	**4 hours**

Advantages & disadvantages of PLC with respect to relay logic, PLC architecture, Input Output modules, PLC interfacing with plant, memory structure of PLC.

Module:2	**PLC Programming Methodologies:**	**4 hours**

Ladder diagram, STL, functional block diagram, SFC, Instruction List. Creating ladder diagram from process control descriptions, Introduction to IEC61131 international standard for PLC.

Module:3	**PLC Functions:**	**4 hours**

Bit logic instructions, ladder diagram examples, interlocking, latching, inter dependency and logical functions, PLC Timer & Counter functions on-delay timer, off-delay timers, retentive on-delay timers, pulse timers, timer examples, up-counter, down-counter and up-down counter, counter examples, register basics.

Module:4	**PLC Data Handling:**	**4 hours**

Data move instructions, table and register moves, PLC FIFO & LIFO functions. PLC arithmetic and logical functions: addition, subtraction, multiplication, division instructions, increment decrement, trigonometric and log functions, AND, OR, XOR, NOT functions, PLC compare and convert functions. PLC program control and interrupts: jumps, subroutine, sequence control relay.

Module:5	**Automation System Structure:**	**4 hours**

Instrumentation Subsystem, Control Subsystem – HMI in Automation, Human Interface Subsystem, Advance Human Interface System.

Module:6	**Introduction to SCADA:**	**4 hours**
Data acquisition system, Evolution of SCADA, Communication Technologies, Monitoring and Supervisory Functions.		
Module:7	**Distributed Control Systems:**	**4 hours**
DCS detail engineering, specifications, configuration and programming, functions including database management, reporting, alarm management, communication, third party interface, control, display etc. Enhanced functions viz. Advance Process Control, Batch application, Historical Data Management, OPC support, Security and Access Control etc. Performance Criteria for DCS and other automation tools.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1. W.Boldon, 'Programmable logic controllers', 5th Edition, Elsevier India Pvt. Ltd., New Delhi, 2011.
2. Stuart A.Boyer, "SCADA: 'Supervisory control and Data Acquisition', 4th Edition, ISA, 2010.

Reference Books

1. G. K. McMillan, Douglas Considine, "Process/Industrial Instruments Hand book", 5th edition, McGraw Hill, New York, 2009.
2. Robert Radvanovsky, Jacob Brodsky, "Handbook of SCADA/Control Systems Security", 2nd edition, CRC press, 2016.
3. Natalia Olifer, Victor Olifer, "Computer networks: Principles, Technologies and protocols for Network design", John Wiley & Sons, 2010.

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

List of Challenging Experiments (Indicative)		
1.	Analysis of timer and counter functions using PLC	2 hours
2.	Batch process control and Sequential control using PLC	2 hours
3.	Controlling a pick and place robotic arm	2 hours
4.	Controlling a material handling conveyor	2 hours
5.	Controlling a gantry crane	2 hours
6.	Controlling a 3-axis positioner	2 hours
7.	HMI module interface and coding with PLC for pick and place robotic arm	2 hours
8.	HMI module interface and coding with PLC for material handling	2 hours
9.	HMI module interface and coding with PLC for gantry crane	2 hours
10.	HMI module interface and coding with PLC for 3-axis positioner	2 hours
11.	PID Control Implementation Using PLC	2 hours
12.	Program Control Instruction – MCR	2 hours
13.	Data Acquisition and Control	2 hours
14.	Fuzzy Logic Control Implementation	2 hours
15.	PLC Interfacing	2 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment: Assignments / FAT

Recommended by Board of Studies	**05/03/2016**

Approved by Academic Council	40th AC	Date	18/03/2016

EEE5018	Industrial Robotics	L	T	P	J	C
		3	0	0	0	3

Pre-requisite	NIL	Syllabus version
Anti-requisite	NIL	v. 1.1

Course Objectives:

1. Introduce the concept of robotic control and automation specifically in the area of robotics
2. Introduce autonomy, and rapid re-tasking of intelligent robots and automation technologies
3. Understand smart manufacturing and cyber physical systems applications using robots.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Select an appropriate robot type for a specific manufacturing application.
2. Analyze the manipulator design including actuator, drive and sensor issues.
3. Calculate the forward kinematics, inverse kinematics of position and orientation.
4. Calculate Jacobian for serial and parallel robots.
5. Develop programming principles and languages for a robot control system.
6. Model, simulate and study the dynamic behavior of robotic links.
7. Develop skills in sensor integration in the area of robotics and automation, which will help in designing a robot for any application.

Module:1	Introduction:	4 hours

History and current trends in robotics, definition, component and structure of robot, degree of freedom and work space, classification of robot, common kinematic arrangement, wrists and end effector, robotic systems.

Module:2	Spatial description and transformation:	6 hours

Position definitions. Coordinate frames. Different orientation descriptions. Free vectors. Translations rotations and relative motion. Composition of rotation, rotation with respect to fixed frame and current frame, parameterization of rotation, Euler Angele, roll, pitch, yaw, axis/angle representation, Homogeneous transformation.

Module:3	Manipulator forwards and inverse kinematics:	6 hours

Link coordinate frames, Denavit - Hartenberg convention, Assignment of coordinate frame, Joint and end-effector Cartesian space. Forward kinematics transformations of position. Inverse kinematics of position and orientation.

Module:4	Mechanics of Robot Motion:	7 hours

Translational and rotational velocities. Velocity Transformations. The Manipulator Jacobian. Forward and inverse kinematics of velocity. Singularities of robot motion.

Module:5	Robot Dynamics:	7 hours

Lagrangian formulation, general expression for kinetic and potential energy of n-link manipulator, Newton-Euler equations of motion. Derivation of equations of motion for simple cases: two-link manipulators. Recursive Newton-Euler formulation.

Module:6	Path planning & Programming:	6 hours

Trajectory planning and avoidance of obstacles.Trajectory for point to point motion,Cubic polynomial trajectory,Quintic polynomial, LSPB(Linear segment with parabolic blend)Minimum time trajectory, Trajectories for Paths Specified by Via Points. Robot languages, computer control and Robot software.		
Module:7	**Industrial Application of Sensors in Robotics:**	**7 hours**
Internal and external sensors, position, velocity and acceleration sensors, proximity sensors, force sensors, laser range finder. Robot vision: image processing fundamentals for robotic applications, image acquisition and preprocessing. Segmentation and region characterization object recognition by image matching and based on features.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**Hours: 45**

Text Book(s)	
1.	M.W. Spong, “Robot Modeling and Control”, 2ND revised edition, Wiley, 2012.
	J.J. Craig, “Introduction to Robotics: Mechanics and Control”, Pearson Education, 2014.
Reference Books	
1.	K.S. Fu, R.C. Gonzales, and C.S.G. Lee, "Robotics: Control, Sensing, Vision and Intelligence," McGraw-Hill, 1987.
2.	Satyaranjan Deb; Sankha Deb, “Robotics Technology and Flexible Automation”, Tata McGraw-Hill, 2010.
3.	S.K. Saha, “Introduction to Robotics”, Tata McGraw-Hill, 2014.
4.	A. Ghosal, “Robotics: Fundamental Concepts and Analysis”, Oxford University Press, 2009.

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

Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE5019	Control of Electric Drives	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. Introduction to different types of drives and applications in various industries.
2. To provide in depth knowledge and various aspects of solid state control of DC and AC drives

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Identify the need and choice of various drives.
2. Design rectifier fed drives for drives applications.
3. Design chopper fed drives for speed and torque control
4. Develop the model, analyze the performance and detect the faults of Induction motor drives.
5. Select and design the control circuits for the various IM Drives.
6. Utilize modern hardware and software tools for control and design of drives
7. Utilize Microprocessors in designing components of the control of Electric Drives

Module:1	Introduction to Power Electronics and Drives:	6 hours

Review the operation of controlled rectifiers, choppers, Inverter. Selection and rating of the drives. Equations governing motor load dynamics - Equilibrium operating point and its steady state stability - Multi quadrant dynamics in the speed torque plane.

Module:2	Control of Rectifier fed drives:	5 hours

Single quadrant, Two –quadrant and four quadrant rectifier fed dc separately excited d.c. motor - Closed loop operation of rectifier fed drive.

Module:3	Control of Chopper fed DC drives:	5 hours

Single quadrant, Two –quadrant and four quadrant chopper fed dc separately excited motor – Closed loop operation of chopper fed drive.

Module:4	Analysis and Modelling of Induction Motor Drive:	8 hours

Dynamic modeling of induction motor, Three phase to two phase transformation-stator, rotor, synchronously rotating reference frame model, Fault detection and diagnosis of rotating machines.

Module:5	Control of Induction Motor Drive:	9 hours

Scalar Control of Induction Motor -Principle of vector control and Field Orientation – Sensor less control and flux observers- Direct Torque and Flux control of induction motor drive.

Module:6	**Control of Special Electrical Machines:**	**5 hours**
Brushless DC motor, Permanent synchronous motor, Switched reluctance motor.		
Module:7	**Embedded Control of Drives:**	**5 hours**
Generation of firing pulses- generation of PWM pulses using embedded processors IC for control of DC drives- fixed frequency/variable frequency/current control- V/F control using PIC microcontroller- vector control using embedded processors.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 Hours**

Text Book(s)	
1.	Bimal K. Bose, "Modern Power Electronics and AC Drives", Pearson Education , 2015.
Reference Books	
1.	Ned Mohan , " Electrical Machines and Drives : A First course", Wiley Publications, 2011.
2.	Paul C. Krause Oleg Wasynczuk Scott D. Sudhoff, "Analysis Of Electric Machinery And Drive Systems", 2nd Edition, Wiley India Pvt Ltd, 2010.
3.	Luo, Fang Lin., Hong Ye; Muhammad H Rashid, "Digital Power Electronics and Applications", Academic Press 2010.
4.	R.Krishnan, "Electric Motor Drives, Modeling, Analysis and Control" Prentice Hall of India, 2008.

Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5020	Machine Learning	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To provide the student with a broad understanding of machine learning algorithms and their applications.
2. The course will also discuss recent applications of machine learning, such as to robotic control, data mining, autonomous navigation, bioinformatics, speech recognition, and text and web data processing.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Solve basic data fitting problems using gradient descent approach.
2. Analyze linear and nonlinear regression problems.
3. Solve pattern classification problems involving multiple cases and texts.
4. Analyze data used for classification and regression analysis using SVM
5. Evaluate dimensionality reduction problems using PCA.
6. Propose solutions for sequential decision making problems using Reinforcement learning by formulating MDP.
7. Choose proper learning methods for the given problems involving continuous variables or higher dimension.
8. Design a component or a product applying all the relevant standards with realistic constraints.

Module:1	**Regression Problem and Gradient Descent:**	**4 hours**

The Motivation & Applications of Machine Learning, Linear Regression, Gradient Descent, Batch Gradient Descent, Stochastic Gradient Descent, The Concept of Under fitting and Overfitting.

Module:2	**Classification Problem and Instance Based Learning:**	**4 hours**

The Concept of Parametric Algorithms and Non-parametric Algorithms, Locally Weighted Regression, The motivation of Logistic Regression, Logistic Regression and Perceptron Learning Algorithm.

Module:3	**Multiple Classes and Text Classification:**	**4 hours**

Softmax Regression. Discriminative Algorithms, Generative Algorithms, Gaussian Discriminant Analysis (GDA) and Naive Bayes algorithm.

Module:4	**Support Vector Machine Algorithm:**	**4 hours**

Intuitions about Support Vector Machine (SVM), Notation for SVM, Functional and Geometric Margins.

Module:5	**Linear Dimensionality Reduction:**	**4 hours**

Principal Component Analysis (PCA), PCA as a Dimensionality Reduction Algorithm, Applications of PCA.

Module:6	**Markov Decision Process and Reinforcement Learning:**	**4 hours**
Applications of Reinforcement Learning, Markov Decision Process (MDP), Defining Value & Policy Functions, Value Function and Optimal Value Function.		
Module:7	**Computing an Optimal Policy:**	**4 hours**
Value Iteration, Policy Iteration. Generalization to Continuous States, Discretization & Curse of Dimensionality and Fitted Value Iteration algorithm.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Tom Mitchell, "Machine Learning", McGraw-Hill Education, 2010.
Reference Books	
1.	Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2013.
2.	Balas K Natarajan, "Machine Learning", Elsevier Science, 2014.

Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5021	Industrial Data Networks	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. The objective of this course is to give an overview of the industrial data communication systems
2. To examine and understand network protocols and architectures.
3. To educate the student in modern networking technologies.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Understand the rudiments of how industrial devices communicate.
2. Infer the standards in network design and ensure the best practice followed in installing and commissioning data networks
3. Recommend Industrial Ethernet protocol for interfacing higher layer devices in automation pyramid.
4. Understand master-slave functioning of Modbus and implement for networking devices like smart meters.
5. Utilize HART handheld controller for calibration of field devices.
6. Recommend Profibus network for interfacing devices like PLCs and local controllers.
7. Design interface for field level devices like sensors and actuators using Fieldbus protocol.

Module:1	**Networks:**	**5 hours**

Introduction to Networks-Advantages and Disadvantages. OSI Model-Foundations of OSI Model. Protocol – Standards.

Module:2	**Physical Interface Standards:**	**5 hours**

EIA 232 overview, EIA 485 overview, EIA 484 Installation, noise problems, current loop & EIA converters

Module:3	**Industrial Ethernet:**	**7 hours**

Introduction-IEEE Standards-Ethernet MAC layer-IEEE 802.2 and Ethernet SNAP- OSI and IEEE 802.3 standard. Ethernet transceivers, Ethernet types, switches & switching hubs, 10 Mbps Ethernet, 100 Mbps Ethernet, Gigabit Ethernet. TCP / IP Overview- Internet Layer Protocols- Host-to-Host layer

Module:4	**Modbus:**	**6 hours**

Overview-Protocol Structure-Example Function codes. Modbus Plus protocol- Overview. Data Highway Plus/DH485 Overview, AS – interface Overview- Layers- Operating Characteristics.

Module:5	**HART Overview:**	**7 hours**

Introduction to HART and smart instrumentation, HART Protocol, Physical layer, Data link layer, and application layer.

Module:6	**ProfiBus overview:**	**6 hours**

Introduction, ProfiBus protocol stack, ProfiBus communication model, communication objects, performance, system operation

Module:7	**Foundation Fieldbus overview:**		**7 hours**
Introduction to Foundation Fieldbus, physical layer and wiring rules, data link layer, application layer and user layer.			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**45 hours**	
Text Book(s)			
1.	Behrouz A. Forouzan, "Data Communications and Networking", Tata McGraw-Hill, 5th edition, 2013.		
2.	Sen, Sunit Kumar. Fieldbus and Networking in Process Automation. CRC Press, 2014.		
Reference Books			
1.	Bela G. Liptak, "Instrument Engineers' Handbook: Process Software and Digital Networks", Third Volume, CRC Press, 2011.		
2.	Verhappen, Ian, and Augusto Pereira. Foundation Fieldbus. ISA, 2012.		
3.	Theodore S. Rappaport, "Wireless Communications: Principles and Practice", 2nd edition, Pearson, 2009.		
4.	Axelsson, Björn, and Geoff Easton, eds. Industrial networks: a new view of reality. Routledge, 2016.		
Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5022	Power Plant Control and Instrumentation	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To provide a detailed insight about the operation and control in thermal power plants.
2. To provide knowledge on various measuring tools for measuring electrical and non-electrical parameters in power plants

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Describe sources of energy and types of power plants.
2. Recommend sensors for measuring electric parameters.
3. Recommend or design sensors and supporting systems for measuring non-electric parameters.
4. Analyze different types of chemicals of different medium and their role in power plant.
5. Plan single or multivariable control strategies for Boiler control.
6. Design controllers for turbine speed, vibration, etc.
7. Measure and draft control strategies polluting parameters.
8. Design a component or a product applying all the relevant standards with realistic constraints.

Module:1	**Energy Sources and Power Generation:**	**4 hours**

Conventional Energy Sources, Non-Conventional Energy Sources. Brief survey of methods of power generation.

Module:2	**Electric Parameter measurements:**	**4 hours**

Current, voltage, power, power factor and frequency measurement. Trivector meter.

Module:3	**Non-Electric Parameter measurements:**	**4 hours**

Flow of feed water, fuel, air and steam with correction factor for temperature – Steam pressure and steam temperature - Drum level measurement.

Module:4	**Analyzers in Power Plants:**	**4 hours**

Fuel gas oxygen analyzer – Analysis of impurities in feed water and steam – Dissolved oxygen analyzer – Chromatography – pH meter - fuel analyzer

Module:5	**Boiler Control:**	**4 hours**

Control and monitoring of combustion process Air to fuel ratio, three element drum level, temperature, pressure, furnace draft, air, water, exhaust gas.

Module:6	**Turbine Control:**	**4 hours**

Speed, Vibration, shell temperature monitoring and control - Steam pressure control – Lubricant oil temperature control – Cooling system.

Module:7	**Pollution monitoring and control:**	**4 hours**

Radiation detector – Smoke density measurement – Dust monitor. Noise Monitor and control. Study of Electrostatic precipitator.

Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	Basu and Debnath, "Power Plant Instrumentation and Control Handbook", Academic Press, 1st Edition, 2014.
2.	K. Krishnaswamy, M. Ponni bala, "Power Plant Instrumentation", PHI Learning pvt ltd., 2013.
Reference Books	
1.	David Lindsley, "Power-plant Control and Instrumentation: The Control of Boilers and HRSG Systems", Institution of Electrical Engineers, 2008.
2.	Alicia C Ortiz; Nancy B Griffin, "Pollution monitoring",Nova Science Publishers, 2011.

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

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5029	Data Acquisition and Hardware Interfaces	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.1				

Course Objectives:

1. To impart an in-depth knowledge in sensor signal conditioning, signal conversion, data acquisition, signal processing, transmission and analysis.
2. To provide a comprehensive coverage of data acquisition methods for sensor systems and hardware interface cards available commercially.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Interpret the elements of data acquisition techniques.
2. Design and simulate signal conditioning circuits.
3. Demonstrate understanding of the principles of instrumentation used in data acquisition
4. Demonstrate understanding of the fundamental graphical programming for instrumentation.
5. Recommend a protocol for standard networking of DAQ devices.
6. Utilize a virtual instrumentation platform for handling file inputs and outputs.
7. Conduct experiment in sensor signal conditioning, and signal conversion, acquisition, signal processing and analysis using LabVIEW.

Module:1	**Fundamentals of Data acquisition:**	**6 hours**

Fundamentals of data acquisition-configuration and structure-interface systems-interface bus. Analog and digital signals. Review of quantization in amplitude and time axis.

Module:2	**Signal conditioners:**	**6 hours**

Signal conditioners- voltage and current amplifiers-voltage conditioners-integrated signal conditioners for temperature sensors, strain gages, piezoelectric sensors and linear position sensors. signal conditioning modules for plug-in board, two-wire transmitter, and distributed I/O - high speed digital transmitter. Field wiring and signal measurement-grounded and floated signal source-single ended and differential ended measurements. ground loop and system isolation-noise and interference- shielding

Module:3	**DAQ boards:**	**7 hours**

Plug-in data acquisition boards-A/D boards- multiplexer and its parameters-input signal amplifiers and its parameters-programmable gain amplifier-channel gain array-sample and hold circuit and its parameters-A/D converters-conversion techniques-parameters-memory buffer- bus interface. resolution, accuracy and dynamic range of A/D boards. sampling and preventing aliasing.

Module:4	**Common interface standards for data acquisition systems:**	**6 hours**

RS232C, RS485, GPIB standard IEEE488.2, Distributed and stand alone data loggers-storage and retrieval- USB, HART Protocol, Foundation Fieldbus, Devicenet, Profibus, Controlnet, and Industrial Ethernet.

Module:5	**Basic Virtual Instrumentation:**	**6 hours**

LabVIEW - Graphical user interfaces - Controls and Indicators - 'G' programming - Data type,

Format,Precision and representation - Data flow programming - Debugging and Running a Virtualinstrument - Functions and Libraries. FOR loops, WHILE loops, CASE structure, formula nodes -Sequence structures.		
Module:6	**Advanced Virtual Instrumentation:**	**6 hours**
Arrays and Clusters Array operations - Bundle - Bundle/Un-bundle by name, graphs and charts - String and file I/O - High level and Low level file I/O's - Attribute modes Local and Global variables.		
Module:7	**Advanced data Acquisition:**	**6 hours**
Measurements using DAQ Cards, Real-Time System, VISA Field Point I/O, Compact RIO I/O and Intelligent Real-Time Embedded Controller. PCI or PXI R Series device, Device Calibration- External Calibration & Internal Calibration.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Maurizio Di Paolo Emilio, "Data Acquisition systems- from fundamentals to Applied Design", Springer, 2013.
Reference Books	
1.	Robert H King, "Introduction to Data Acquisition with LabVIEW", McGraw Hill, 2nd edition, 2012.
2.	Robert H. Bishop, National Instruments, Inc., "LabVIEW Student Edition", Prentice Hall, 2014.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE5030	Flight Control System	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To develop fundamental knowledge and basic concepts on components in aircraft
2. To impart knowledge on operating principles of essential mechanical and electrical systems in aircraft.
3. To develop skills in control system design and analysis related to aircraft.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Demonstrate understanding of the concepts of aircraft automatic control, find out the roles and objectives of flight control.
2. Develop the aircraft equations of motion, and derive the aircraft's response modes.
3. Explain aircraft longitudinal stability and the aerodynamic force and control factors that influence it.
4. Identify the flight control and utility functions to be considered in the design of an aircraft hydraulic system.
5. Analyse the controllability and observability of aerospace systems, and apply the modern control techniques to design enhanced flight control systems.
6. Identify the flight control and utility functions to be considered in the design of an aircraft hydraulic system.
7. Explain the elements of space vehicle attitude determination and control subsystems and describe various technologies currently in use.

Module:1	Introduction:	4 hours

Principles of flight control. Primary and secondary flight controls. Flight phases. Aircraft mass and payload.

Module: 2	Nonlinear Aircraft Model :	6 hours

Definitions of the Frames, Wind Disturbance, Model of the Low Altitude Atmosphere, Equations of Rigid-Body Motion, Engine Rate, Thrust Force, Model of the Aerodynamic Forces: Lift, Lateral, Drag, Model of the Aerodynamic Torques.

Module:3	Aircraft Stability:	7 hours

Static Stability: Degree of freedom of rigid bodies in space, Inherently stable and marginal stable airplanes – Static, Longitudinal stability - Basic equilibrium equation Lateral Stability: Dihedral effect - Lateral control - Coupling between rolling and yawing moments Weather cocking effect – Rudder requirements - One engine inoperative condition.

Module:4	Dynamic stability:	6 hours

Introduction to dynamic longitudinal stability: - Modes of stability, effect of freeing the stick-Brief description of lateral and directional. dynamic stability - Spiral, divergence, Dutch roll, auto rotation and spin.

Module:5	**Control Design:**	**7 hours**
Theory of the Linear Quadratic Problem, Optimal Output Regulator Problem, State Regulators with a Prescribed Degree of Stability, Explicit Model-Following, Optimal Command Control System, Use of Integral Feedback in LQP.		
Module:6	**System Components:**	**7 hours**
Electrical systems: Characteristics of civil aircraft electrical system, Electrical loads, Emergency power generation. Hydraulic Systems: Flight control and utility functions, Emergency power sources, Landing-gear system, Braking and anti-skid. Pneumatic systems: Pitot-static systems, Use of engine bleed air, Bleed air control, Thrust reversers.		
Module:7	**Control Schemes:**	**6 hours**
Pitch Attitude Control Systems, Roll Angle Control Systems, Co-ordinated Turn Systems, Direction Control System, Height Control Systems, Speed Control Systems, VOR-Coupled Automatic Tracking System ILS-Coupled Control System, Automatic Landing System, A Terrain-Following Control System		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Margaret Ziegler,"Automatic flight control systems", Clanrye International, 2015.
2.	I. Moir amd A.G. Seabridge, Design and Development of Aircraft Systems – An Introduction, AIAA Education Series, 1st Edition, 2014.
Reference Books	
1.	Cook, Michael V. Flight dynamics principles: a linear systems approach to aircraft stability and control. Butterworth-Heinemann, 2012.
2.	Thomas R Yechout; Steven L Morris; David E Bossert; Wayne F Hallgren; James K Hall, "Introduction to aircraft flight mechanics : performance, static stability, dynamic stability, classical feedback control, and state-space foundations" AIAA 2014.
3.	McRuer, Duane T., Dunstan Graham, and Irving Ashkenas. Aircraft dynamics and automatic control. Princeton University Press, 2014.

Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE5031	Advanced Reliability Engineering	L	T	P	J	C
		1	2	0	0	2
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. Apply the principles & methods of reliability and maintenance engineering tools for Design problems
2. Understand the importance of reliability and its relationship with quality and safety
3. Application of RAMS to Aero, Medical and Industrial commodities

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Design RAMS as per the standards followed for AERO applications.
2. Develop models and case studies to analyze RAMS for medical devices.
3. Design to meet the reliability and functional safety objectives in the Auto components.
4. Examine the various reliability test strategies and standards for Industrial systems.
5. Analyze RAMS in the user specific applications.
6. Integrate different case studies for the utilizations of RAMS in specific applications.
7. Develop the reliability predictive models using software tools.

Module:1	RAMS - AERO	5 hours

RAMS in Aerospace Domain, ARP 4761 and ARP 4754 - System Safety Assessment Process. Introduction to DO-178, DO-254 and DO - 160 E Standards. Process FMEA, MSG 3 Analysis, RAMS Case Study on Aero Program.

Module:2	RAMS - MEDICAL	5 hours

RAMS in Medical Domain, Medical Devices - Classification and Applicable Reliability and Risk Management Tasks, Standards - ISO 14971, ISO 13485. PMS - Post Market Surveillance in Medical Devices - RAMS Case Study on Medical Devices

Module:3	RAMS - AUTO	4 hours

RAMS in Auto Domain, DFR Process in Auto Domain, ISO 26262 - Functional Safety, ITAF 16949 Standard. Warranty Data Management. RAMS Case Study - Auto Systems.

Module:4	RAMS - INDUSTRIAL, ROBOTS	4 hours

RAMS in Industrial Domain, IEC 61508 - Functional Safety Standard. RAMS Case Study on Industrial Systems.

Module:5	RAMS - APPLIANCES, OFFICE AUTOMATION PRODUCTS, CONSUMER ELECTRONICS	4 hours

RAMS in Appliances, Office Automation Product and Consumer Electronics - Case Study From Each Domain.

Module:6	**TUTORIALS- I**		**4 hours**
Domain Specific Reliability and Safety Plan			
Module:7	**TUTORIALS – II**		**4 hours**
Reliability Test Planning - Reliasoft ALTA++ Test Planning, Test Data Analysis			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	Louis J. Gullo and Jack Dixon, "Design for Safety-Quality and Reliability Engineering Series", John Wiley & Sons, 2017.
Reference Books	
1.	B S Dhillon, "Robot System Reliability and Safety: A Modern Approach", CRC Press-Taylor & Francis, 2015.
2.	Nicholas J. Bahr, "System Safety Engineering and Risk Assessment: A Practical Approach", Second Edition, CRC Press-Taylor & Francis, 2015.
3.	Richard C. Fries, "Reliable Design of Medical Devices", Third Edition, CRC Press-Taylor & Francis, 2013.
4.	Clifton A. Ericson II, "Hazard Analysis Techniques for System Safety", First Edition, John Wiley & Sons, 2005.

Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**13-10-2018**		
Approved by Academic Council	**53rd**	Date	**13-12-2018**

EEE5032	Building Automation	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To impart knowledge on various systems involved in a building management system.
2. To give exposure on factors influencing controller design for building automation

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Understand the importance of building automation
2. Design fire alarm system for building automation
3. Design access control system with enhanced security
4. Explain the various components of HVAC
5. Design and implement controllers for BAS to meet various factors.
6. Maximize the efficiency of energy management system.
7. Recommend a building management system for a given problem.

Module:1	**Introduction:**	**4 hours**

Concept and application of Building Management System (BMS) and Automation, requirements and design considerations and its effect on functional efficiency of building automation system, architecture and components of BMS

Module:2	**Fire Alarm System:**	**6 hours**

Fundamentals: Fire modes, History, Components, and Principles of Operation. FAS Components: Different fire sensors, smoke detectors and their types, Fire control panels, design considerations for the FA system. Field Components, Panel Components, Applications. FAS Architectures: Types of Architectures, Examples. FAS loops: Classification of loops, Examples. Fire Standards: FAS Design procedure in brief, NFPA 72A, BS 5839, IS Concept of IP enabled fire & alarm system, design aspects and components of PA system.

Module:3	**Access Control System:**	**8 hours**

CCTV: Camera: Operation & types, Camera Selection Criteria, Camera Applications, DVR Based system, DVM, Network design, Storage design. Components of CCTV system like cameras, types of lenses, typical types of cables, controlling system.

Security Design: Security system design for verticals. Concept of automation in access control system for safety, Physical security system with components, RFID enabled access control with components, Computer system access control – DAC, MAC, RBAC.

Module:4	**HVAC system:**	**8 hours**

Fundamentals: Introduction to HVAC, HVAC Fundamentals, Basic Processes (Heating ,Cooling etc)

Basic Science: Air Properties, Psychometric Chart, Heat Transfer mechanisms, Examples.

Human Comfort: Human comfort zones, Effect of Heat, Humidity, Heat loss.

Processes: Heating Process & Applications (I.e. Boiler, Heater), Cooling Process & Applications (I.e. Chiller), Ventilation Process & Applications (I.e. Central Fan System, AHU, Exhaust Fans), Unitary Systems (VAV, FCU etc).		
Module:5	**Control System:**	**5 hours**
Instrumentation Basics, Field components & use, DDC, DCS & applications. Control Panel: HVAC Control Panel, MCC Basics, Panel Components Communication: Communication Basics, Networks, BACNet, Modbus , LON		
Module:6	**Energy Management System:**	**6 hours**
ASHRAE Symbols -Energy Management: Energy Savings concept & methods, Lighting control, Building Efficiency improvement, Green Building, Concept & Examples.		
Module:7	**Building Management System:**	**6 hours**
BMS (HVAC, Fire & Security) project cycle, Project steps BMS. Verticals: Advantages & Applications of BMS, Examples Integration: IBMS. Architecture, Normal & Emergency operation. Advantages of BMS		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Reinhold A. Carlson, Robert A. Di Giandomenico, "Understanding Building Automation Systems (Direct Digital Control, Energy Management, Life Safety, Security, Access Control, Lighting, Building Management Programs), R.S. Means Company, 1991.
2.	Jim Sinopoli, Butterworth-Heinemann, "Smart Buildings", imprint of Elsevier,2nd ed., 2010.
3.	Albert Ting-Pat So, WaiLok Cha , "Intelligent Building Systems", Kluwer Academic publisher,3rd ed., 2012.
Reference Books	
1.	Robert Gagnon, "Design of Special Hazards and Fire Alarm Systems", Thomson Delmar Learning; 2nd edition, 2007.
2.	Michael F. Hordeski, "HVAC Control", New Millennium, Fairmont Press, 2001

Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**10th August 2018**		
Approved by Academic Council	**53rd**	Date	**13/12/2018**

EEE6011	Optimal Control Systems	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.1				

Course Objectives:

1. Optimal control fundamentals
2. Dynamic programming for optimal control
3. Constrained optimal control
4. Numerical methods of solving optimal control problems

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Formulate optimal control problem and Select the performance index for the optimal problem
2. Estimate an optimal solution for the given problem
3. Design an optimal control law using dynamic programming technique for a practical dynamic systems
4. Propose variational approach to solve optimal control problem
5. Design a controller for tracking and regulatory problems with constraints
6. Design a controller for achieving the desired output in minimum time and with optimal control effort
7. Design different numerical techniques to solve optimal control problem

Module:1	**Introduction:**	**6 hours**

Problem formulation – Mathematical model – Physical constraints – Performance measure: Form of optimal control - Performance measures for optimal control problem – Selecting a performance measure.

Module:2	**Calculus of Variations:**	**8 hours**

Fundamental concepts – Functionals - Piecewise–smooth extremals - Constrained extrema

Module:3	**Dynamic Programming:**	**7 hours**

Optimal control law – Principle of optimality - An optimal control system – Interpolation - a recurrence relation of dynamic programming – computational procedure - Characteristics of dynamic programming solution.

Module:4	**Linear Regulator & Variational Approach:**	**5 hours**

Hamilton–Jacobi–Bellman equation - Continuous linear regulator problems - Variational approach to optimal control problems: Necessary conditions for optimal control.

Module:5	**Optimal Regulator & Tracking problems:**	**6 hours**

Linear regulator problems - Linear tracking problems - Pontryagin's minimum principle and state inequality constraints.

Module:6	**Optimal Time & Control Effort Problems:**	**5 hours**

Minimum time problems – Minimum control–effort problems - Singular intervals in optimal control problems.

Module:7	**Numerical determination of optimal trajectories:**	**6 hours**
Two point boundary–value problems - Method of steepest decent - variation of extremals – Quasilinearization - Gradient projection algorithm – Case studies.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Donald E. Kirk, "Optimal Control Theory: An Introduction", Dover Publications, 2012.
Reference Books	
1.	Frank Lewis, Draguna L. Vrabie, Vassilis L. Syrmos, "Optimal Control", 3rd edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2012
2.	Leonid T Aschepkov; Dmitriy V Dolgy; Taekyun Kim; Ravi P Agarwal,"Optimal Control", Springer, 2016.
Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar	

Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE6012	Adaptive and Robust Control	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

The objective of this course is to expose the students to

1. Techniques of system identification and design of Adaptive Control Systems.
2. Analyze uncertain systems and design robust control systems.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Understand Various System Identification Techniques.
2. Design self-tuning regulators for adaptive control.
3. Design model based adaptive control strategies.
4. Understand variable structure systems and design sliding mode control.
5. Analyze stability of systems with unstructured uncertainty.
6. Design robust control loops satisfying system norms.
7. Utilize simulation platform to design, implement and test adaptive and robust control strategies.
8. Design a component or a product applying all the relevant standards with realistic constraints.

Module:1	**Adaptive Control**:	**4 hours**

Introduction, Linear Feedback, Effects of Process Variations, Adaptive Schemes, the Adaptive Control Problem. Real-Time Parameter Estimation - Least Squares and Regression Models, Estimating Parameters in Dynamical Systems.

Module:2	**Self-Tuning Regulators (STR):**	**4 hours**

Introduction, Pole Placement Design, Direct and Indirect Self-tuning Regulators, Stochastic Self-tuning Regulators Continuous-Time Self-tuners, Unification of Direct Self-tuning Regulators, Linear Quadratic STR, Adaptive Predictive Control

Module:3	**Model-Reference Adaptive Systems (MRAS):**	**4 hours**

Introduction, The MIT Rule, Lyapunov Theory, Design of MRAS Using Lyapunov Theory, Bounded-Input &Bounded-Output Stability, Applications to Adaptive Control, Output Feedback, Relations between MRAS and STR.

Module:4	**Sliding Mode Control:**	**4 hours**

Sliding Surfaces- Continuous approximations of Switching Control laws-The Modeling/Performance Trade-Offs- Multi Input systems

Module:5	**Model Uncertainty:**	**4 hours**

Model uncertainty - Stability under Unstructured Uncertainties - Small Gain Theorem and robustness - μ- Analysis and Synthesis: Consideration of Robust performance

Module:6	**H_2 Control:**	**4 hours**

Standard and Extended LQR Problem – Characterization of H_2 controllers – Kalman Bucy Filter as special H_2 Estimator – LQG as special H_2 controller

Module:7	**Case Studies:**	**4 hours**
Case studies using MATLAB/ Robust Control toolbox. Implementation of Adaptive Control techniques in MATLAB		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Karl J Astrom, B, Jorn Wittenmark, "Adaptive Control ", Courier Corporation, 2nd Edition, 2013.
2.	Hasan Khalil, “Nonlinear systems and control”, Prentice Hall, 2014.
Reference Books	
1.	Shankar Sastry, Marc Bodson, "Adaptive Control: Stabilty, Convergence and Robustness", Dover Publications , 1st Edition, 2011.
2.	Mackenroth U. “Robust Control Systems, Theory and Case Studies”, Springer India Pvt. Ltd, New Delhi, 2010.
Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar	

Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE6013	Discrete Control Systems	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.1				

Course Objectives:

1. To impart the in-depth knowledge of control theory, design of different controllers, analysis of discrete systems by state space analysis.
2. To analyze the concepts of implementing DSP algorithms using DSP processors.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Analyze discrete-time closed-loop systems by using the z-transform.
2. Propose the model and analyze the response and stability of systems in discrete domain.
3. Design and realize digital controllers.
4. Develop the discrete models of SISO and MIMO processes.
5. Design controllers and observers in discrete domain.
6. Develop an understanding of design issue like sampling rate selection, quantization effects.
7. Utilize modern digital tools to handle discrete control system.

Module:1	**Introduction to Discrete Control System:**	**6 hours**

Introduction- continuous versus digital control- sampling process- effect of sampling rate. Discrete time system representation. Z-transform. Mapping of s-plane to z-plane.

Module:2	**Discrete Time System Modelling and Response:**	**6 hours**

Pulse transfer function-Signal flow graph. Stability analysis-Jury Stability-Bilinear transformation. Time Response: Transient and steady state response of second order system

Module:3	**Design of Digital Controller:**	**8 hours**

Discretization of continuous transfer functions; Controller design using transformation techniques: Z-plane specifications. Design in the w domain. PID controller. Root Locus design.

Module:4	**Discrete state space model:**	**7 hours**

Introduction to state space-state equation-solutions-conversion of state space to transfer function-state space modeling-solution to discrete state equation.

Module:5	**Design via State space:**	**8 hours**

Controllability-Observability- stability-Pole placement by state feedback-Full order observer design-Reduced order observer design.

Module:6	**Quantization effects:**	**4 hours**

Quantization effects**.** Truncation and Rounding off error – SNR- Limit cycles and dither. Sample rate reduction.

Module:7	**Microprocessor and DSP control**:		**4 hours**
Mechanization of control algorithms. Iterative computation via parallel, direct, canonical, cascade realization; Effects of computing time. Systems with time delay. Case studies.			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**45 hours**	
Text Book(s)			
1.	M. Gopal, "Digital Control and State Variable Methods: Conventional and Intelligent Control", Tata McGraw Hill, 4th Edition, 2014 (Reprint).		
2.	Yoshifumi Okuyama, "Discrete Control Systems", Springer, 2016.		
Reference Books			
1.	K. Ogata, "Discrete-time control systems", New Delhi : Prentice-Hall of India, 2009.		
2.	Norman S. Nise," Control systems Engineering", John Wiley and Sons, 7th Edition, 2015.		
Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			

Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**

EEE6014	Fault Detection and Diagnosis	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**EEE5013**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To familiarize the students with the basic principles of FDD
2. To introduce different data driven methods for FDD

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Understand the types of faults and their impact on the given system.
2. Analyze and represent faults mathematically.
3. Design residual generators for fault detection and isolation.
4. Recommend residual structure for single and multiple fault isolation problems.
5. Develop knowledge on the design for directional residuals
6. Propose Fault Detection and Isolation methods for parametric faults.
7. Function on different data driven methods for FDD
8. Design a component or a product applying all the relevant standards with realistic constraints

Module:1	**Introduction to Fault Detection and Diagnosis (FDD):**	**4 hours**

Scope of FDD: Types of fault and different tasks of fault detection and implementation – Different approaches of FDD: Model free and model based approaches. Classification of fault and disturbances – Different issues involved in FDD – Typical applications.

Module:2	**Analytical Redundancy Concepts:**	**4 hours**

Introduction – Mathematical representation of faults and disturbances -Additive and multiplicative faults.

Module:3	**Residual generations:**	**4 hours**

Detection, Isolation, Computational properties and stability – Design of residual generators: Residual specifications and implementation.

Module:4	**Design for structured residuals:**	**6 hours**

Introduction - Residual structure of single fault isolation: Structural definitions and canonical structures – Residual structure for multiple fault isolation: Diagonal structure and full row canonical sets – Introduction to parity equation implementation and alternative interpretation.

Module:5	**Design for directional structured residuals:**	**3 hours**

Introduction – Directional specifications: Directional specification with and without disturbances – Parity equation implementation.

Module:6	**Residual Generation for Parametric Faults:**	**4 hours**

Introduction– Representation of parametric faults– Design for parametric faults and model errors - Kalman filter based FDI

Module:7	**Data driven methods:**	**3 hours**
Principle component analysis - Partial least squares – Canonical variate analysis – Knowledge based methods.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Steven X. Ding, Model based Fault Diagnosis Techniques: Schemes, Algorithms, and Tools, Springer Publication, 2015.
2.	Isermann, Rolf, "Fault-diagnosis systems: an introduction from fault detection to fault tolerance", Springer, 2011.
Reference Books	
1.	Mangoubi, Rami S. Robust estimation and failure detection: A concise treatment. Springer Science & Business Media, 2012.
2.	Martinez-Guerra, Rafael, and Juan Luis Mata-Machuca. Fault detection and diagnosis in nonlinear systems. Springer, 2016.

Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th AC**	Date	**18/03/2016**

EEE6015	SCADA Systems and Applications	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To provide details on the role of Computers and Communication in industrial automation.
2. To deal with the communication protocols and control of power systems using EMS. Open Systems, protocols for power system protection and relaying under IEC 61850 will also be covered in this course.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Propose SCADA nomenclature and their components
2. Design and analyze real time applications using Programmable logic controller (PLC) and SCADA
3. Describe the typical architecture of a SCADA system
4. Evaluate network protocols that provide interoperability and communication technologies
5. Analyze, control and management of power system components through a SCADA system.
6. Propose SCADA for various utilities.
7. Recommend necessary support for third party device interface and security issues in SCADA system.

Module:1	**Introduction to SCADA:**	**4 hours**

Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisory functions.

Module:2	**Introduction to PLC:**	**6 hours**

Block diagram, programming languages, Ladder diagram, Functional block diagram, Applications, Interfacing of PLC with SCADA.

Module:3	**SCADA system components and Architecture:**	**8 hours**

Components: Schemes, Remote Terminal Unit, Intelligent Electronic Devices, Communication Network, SCADA server. SCADA Architecture: Various SCADA Architectures, advantages and disadvantages of each system, single unified standard architecture IEC 61850 SCADA / HMI Systems.

Module:4	**SCADA Communication:**	**7 hours**

Various industrial communication technologies- wired and wireless methods and fiber optics, open standard communication protocols.

Module:5	**Operation and control of interconnected power system:**	**7 hours**

Automatic substation control, SCADA configuration, Energy management system, system operating states, system security, state estimation.

Module:6	**SCADA applications:**	**5 hours**

Utility applications, transmission and distribution sector operation, monitoring analysis and improvement. Industries oil gas and water. Case studies, implementation, simulation exercises.

Module:7	**OPC Support and SCADA Security:**		**6 hours**
Evolution from DDE, COM, OPC Specifications: DA, AE, HDA, Batch, UA, Components and Control – ActiveX – SCADA Security Architecture: Commercial hardware and software vulnerability , Traditional security features, Eliminating the vulnerability			
Module:8	**Contemporary issues:**		**2 hours**
	Total Lecture hours:	**45 hours**	
Text Book(s)			
1.	Stuart A Boyer, SCADA supervisory control and data acquisition, ISA, 4th edition, 2010.		
2.	Ronald L Krutz, "Securing SCADA Systems", Wiley, 2015.		
Reference Books			
3.	Mini S. Thomas, John Douglas McDonald , "Power System SCADA and Smart Grids", CRC Press, 2015.		
4.	Jim Ras, "Cyber security for SCADA systems" , LULU COM, 2016.		
Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	**05/03/2016**		
Approved by Academic Council	**40th**	Date	**18/03/2016**

EEE6016	Modelling and Simulation of Electrical Systems	L	T	P	J	C
		2	0	0	4	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.0				

Course Objectives:

1. To understand the importance of Modeling and simulation using MATLAB technique applied to dynamic systems
2. To implement modeling and simulation technique to control systems, Power electronics and drives , Robotics and Vehicle applications

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Apply MATLAB to first order and second order systems
2. Apply Laplace transform and to design LVDT and other electrical engineering simulation using finite element analysis and MATLAB
3. Create a model and simulate the various mechanical, electrical , hydraulic and pneumatic systems using MATLAB and their toolboxes.
4. Create a model and simulate the various control systems using soft computing methods with MATLAB and their toolboxes.
5. Evaluate power electronics and drives applications using MATLAB/SIMULINK and Dspace.
6. Evaluate robot applications using MATLAB/SIMULINK and Dspace.
7. Evaluate Vehicle applications using MATLAB/SIMULINK and genetic algorithm
8. Design a component or a product applying all the relevant standards with realistic constraints.

Module:1	**Introduction to modeling**	**3 hours**

Introduction to modeling, examples of modeling , modeling of dynamic systems , introduction to simulation , Matlab as a simulation tool, Dynamic response of 1st order and second order system , systems transfer functions, transfer functions of first order and second order system

Module:2	**Engineering Methods and Software Support in the MATLAB & Simulink Programming Environment**	**3 hours**

Numerical Inverse Laplace Transforms for Electrical Engineering Simulation , Linear Variable Differential Transformer Design and Verification Using MATLAB and Finite Element Analysis

Module:3	**Basic system modeling**	**3 hours**

Mechanical systems, electrical systems, hydraulic systems, pneumatic systems, Modeling and simulation of simple and compound pendulum , Modeling and simulation of planar mechanisms.

Module:4	**Modeling, simulation of various control systems using soft-computing methods**	**4 hours**

Modeling, simulation of various control systems using soft-computing methods (fuzzy,fuzzy neuro, genetic and hybrid modeling methods). Parameter estimation methods , parameter estimation examples, system identification, introduction to optimization, optimization with modeling of engineering problems.

Module:5	**Power Electronics and Drives applications**	**6 hours**
MATLAB Co-Simulation Tools for Power Supply Systems Design , Automatic Modelling Approach for Power ElectronicsConverters: Code Generation (C S Function, Modelica,VHDL-AMS) and MATLAB/Simulink Simulation , PV Curves for Steady-State Security Assessment with MATLAB, Implementation of Induction Motor Drive Control Schemes in MATLAB/Simulink/dSPACE Environment, Linearization of Permanent Magnet Synchronous Motor Using MATLAB and Simulink		
Module:6	**Robot Applications**	**4 hours**
Design and Simulation of Legged Walking Robots in MATLAB® Environment, modeling and simulation of wheeled mobile robot, validation and verification of simulation models		
Module:7	**Vehicle applications**	**5 hours**
Robust Control of Active Vehicle Suspension Systems Using Sliding Modes and Differential Flatness with MATLAB, Automatic Guided Vehicle Simulation in MATLAB by Using Genetic Algorithm		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30hours**

Project:	# Generally a team project [5 to 10 members] # Report in Digital format with all drawings using MATLAB software package to be submitted. # Assessment on a continuous basis with a minimum of 3 reviews.	60 [Non Contact hrs]

Text Book(s)

1.	Katsuhiko Ogata, 'Matlab for control engineers, Prentice Hall, 2008 .

Reference Books

1.	Karel Perutka "MATLAB for Engineers – Applications in Control, Electrical Engineering, IT and Robotics" InTech ,2011

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

List of Projects:

1.	Design of PID controller for d.c. motor	2 hours
2.	Modelling and simulation of active suspension system	2 hours
3.	Linear Variable Differential Transformer Design and Verification Using MATLAB and Finite Element Analysis	2 hours
4.	Modelling and simulation of Inverted pendulum	2 hours
5.	Modelling, simulation of control systems using soft-computing methods	2 hours
6.	Optimization with modelling of engineering problems	2 hours
7.	MATLAB Co-Simulation Tools for Power Supply Systems	2 hours
8.	Design , Automatic Modelling Approach for Power Electronics Converters: Code Generation and MATLAB/Simulink	2 hours
9.	PV Curves for Steady-State Security Assessment with MATLAB	2 hours
10.	Implementation of Induction Motor Drive Control Schemes in MATLAB/Simulink/dSPACE Environment	2 hours

11.	Linearization of Permanent Magnet Synchronous Motor Using MATLAB and Simulink	2 hours
12.	Design and Simulation of Legged Walking Robots in MATLAB® Environment	2 hours
13.	Modeling and simulation of wheeled mobile robot, validation and verification of simulation models	2 hours
14.	Robust Control of Active Vehicle Suspension Systems Using Sliding Modes and Differential Flatness with MATLAB	2 hours
15.	Automatic Guided Vehicle Simulation in MATLAB by Using Genetic Algorithm	2 hours
Mode of Evaluation**:** Assignments / FAT		**30 hours**

Recommended by Board of Studies	**13-10-2018**		
Approved by Academic Council	**53rd**	Date	**13-12-2018**

EEE6021	Multivariable Control System	L	T	P	J	C
		3	0	0	0	3
Pre-requisite	**NIL**	**Syllabus version**				
Anti-requisite	NIL	v. 1.1				

Course Objectives:

1. To provide in depth knowledge of multivariable control design.
2. To elaborate concepts of decentralized control and different decoupling schemes.

Expected Course Outcome:

On the completion of this course the student will be able to:

1. Develop model of a multivariable process
2. Analyze Multivariable Systems Multi - loop control Schemes
3. Interpret MIMO systems into interconnected SISO systems
4. Interpret MIMO systems into series of independent SISO systems
5. Interpret MIMO systems using state space analysis
6. Design controllers for MIMO systems using optimization algorithms
7. Understand tradeoffs of different control strategies

Module:1	**Introduction to Multivariable Control & Linear System representation:**	**6 hours**

Multivariable systems – objectives of modelling – Types of Model – Linear models and linearization – input/output representations – discretised models – Disturbance models.

Module:2	**Linear System Analysis & Control problem solutions:**	**7 hours**

Linear system time response – stability conditions – gain – frequency response - system internal structure – Block system structure - model reduction – Solutions to the control problem: variable selection – control structures – two degree of freedom controller - hierarchical control.

Module:3	**Decentralized Control:**	**6 hours**

Introduction – Plant decomposition, grouping of variables – Multi-loop control and paring selection: relative gain array(RGA) , integrity, diagonal dominance – RGA properties and application.

Module:4	**Decoupled Control:**	**6 hours**

Decoupling schems: ideal , simplified, static, feedforward, feedback, SVD ,cascade – Sequenctial-Hierarchical design and tuning.

Module:5	**Centralised Closed-loop Control:**	**6 hours**

State feedback – output feedback – rejection of deterministic unmeasurable disturbances –case study.

Module:6	**Optimisation based control:**	**6 hours**

Optimal state feedback – optimal output feedback – predictive control – Generalised optimal disturbance rejection problem – case study.

Module:7	**Designing for Robustness and implementation:**	**6 hours**

Uncertainty and feedback – trade-offs and design guidelines – robustness analysis methodologies – controller synthesis – control implementation – implementation technologies - Control Schemes for Distillation Column, CSTR, Bioreactor, Four-tank system, pH, and polymerization reactor

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

Text Book(s)	
1.	Albertos, Pedro, Antonio Sala, "Multivariable Control Systems: An Engineering Approach" , Springer, 2010.
Reference Books	
1.	Sigurd Skogestad, Ian Postlethwaite," Multivariable Feedback Control: Analysis and Design", Wiley, 2014.
2.	B.Wayne Bequette, "Process Control: Modeling, Design, and Simulation", 9th print, Prentice hall, 2010.

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

Recommended by Board of Studies	**22/07/2017**		
Approved by Academic Council	**47th AC**	Date	**05/10/2017**