M. TECH – AUTOMOTIVE ELECTRONICS
Department of Electronics and Communication Engineering

India is becoming a premier Automobile hub of the world, with all the automobile giants having a presence in India. The quality and skills of the automotive engineers being developed needs to be sharpened in order to satisfy the stringent requirements of the Automobile industry. The M.Tech. Programme in Automotive Electronics, offered at Amrita School of Engineering, Coimbatore by the Department of Electronics and Communication Engineering is focused on the design of modern electronic systems for automotive applications.

The M.Tech in Automotive Electronics is a truly interdisciplinary programme that provides the students an opportunity to not only learn the traditional industry-relevant aspects of automotive systems, but also gives them an opportunity to specialize in emerging areas such as Advanced Driver Assistance Systems (ADAS), Electrification and Vehicular Communication systems through a rich set of electives. Additionally, most of the courses offered in the curriculum are supported by a standard learning tool (Software/ Hardware) accepted by the scientific community. This learning-by-doing philosophy adds value to the program, so that the students are well prepared to handle the challenges offered by the rapidly changing and evolving automotive industry.

Program Educational Objectives (PEO)

PEO1: To acquire knowledge and skills in electronics and computation in wider aspects of automotive domain to excel in modern industry, academia or research.

PEO2: To comprehend, analyze, design, and create novel solutions to problems in the areas of Automotive Electronics that are viable and acceptable technically, economically and socially.

PEO3: To exhibit professional competence and leadership qualities with a harmonious blend of ethics leading to an integrated personality development.

Program Outcomes (PO)

PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	An ability to demonstrate a degree of mastery over the area as per the specialization of the program
PO4	An ability to use modern tools for engineering design problems, analyze the performance and optimize the systems-level approaches.
PO5	An ability to engage in independent and life-long learning in the context of technological change and industrial demands.

CURRICULUM

Semester – I

Type	Code	Course Name	Teaching Schemes			Credits
			L	T	P	
FC	21AL601	Embedded Computing and Programming	3	0	0	3
FC	21AL602	Machine Learning & Algorithm Design	3	0	0	3
SC	21AL611	Principles of Automotive Systems	3	0	0	3
SC	21AL612	Electric Vehicles and Architectures	3	0	0	3
SC	21AL613	Digital Control Systems	3	0	0	3
SC	21AL681	Embedded Systems and Machine Learning Lab	0	0	4	2
SC	21AL682	Automotive Systems Lab	0	0	4	2
HU	21HU601	Amrita Value Program				P/F
HU	21HU602	Career Competency- I				P/F
		Total	15	0	8	19

Semester – II

Type	Code	Course Name	Teaching Schemes			Credits
			L	T	P	
SC	21AL614	Vehicle Dynamics & Control	3	0	0	3
SC	21AL615	RTOS in Multi-core Environment	3	0	0	3
E		Elective-1	3	0	0	3
E		Elective-2	3	0	0	3
E		Elective-3	3	0	0	3
SC	21AL683	Automotive Testing Lab	0	0	4	2
SC	21AL684	Automotive Control and Vehicle Simulation Lab	0	0	4	2
SC	21RM601	Research Methodology	2	0	0	2
HU	21HU603	Career Competency – II	0	0	2	1
		Total	17	0	10	22

Semester – III

Type	Code	Course Name	Teaching Schemes			Credits
			L	T	P	
E		Open Elective *	3	0	0	3
SC	21LIV601*	Open Lab / Live-in Lab	0	0	4	2
P	21AL798	Dissertation Phase – I	0	0	20	10
		Total	3	0	24	15

*Open Elective can be either a regular course on campus or based on any online learning platforms such as NPTEL/SWAYAM, Coursera, Edx etc.
* 21LIV601-Code for Live- in- Lab

Semester – IV

Type	Code	Course Name	Teaching Schemes			Credits
			L	T	P	
P	21AL799	Dissertation Phase – II	0	0	28	14
		Total	0	0	28	14

Total Credits: 70

List of Courses

Foundation Core

Code	Course Name	Teaching Schemes			Credits
		L	T	P	
21AL601	Embedded Computing and Programming	3	0	0	3
21AL602	Machine Learning & Algorithm Design	3	0	0	3

Subject Core

Code	Course Name	Teaching Schemes			Credits
		L	T	P	
21AL611	Principles of Automotive Systems	3	0	0	3
21AL612	Electric Vehicles and Architectures	3	0	0	3
21AL613	Digital Control Systems	3	0	0	3
21AL614	Vehicle Dynamics & Control	3	0	0	3
21AL615	RTOS in Multi-core Environment	3	0	0	3
21RM601	Research Methodology	2	0	0	2
21AL681	Embedded Systems and Machine Learning Lab	0	0	4	2
21AL682	Automotive Systems Lab	0	0	4	2
21AL683	Automotive Testing Lab	0	0	4	2
21AL684	Automotive Control and Vehicle Simulation Lab	0	0	4	2

Electives

Code	Course Name	Teaching Schemes			Credits
		L	T	P	
21AL701	Vehicular Communication	3	0	0	3
21AL702	Vehicular Networks	3	0	0	3
21AL703	Cryptography and Network Security	3	0	0	3
21AL711	Power Converters for Automotive Applications	3	0	0	3

21AL712	Electrical Machines for Automotive Applications	3	0	0	3
21AL713	Control of Power Converters and Electrical Machines	3	0	0	3
21AL721	Sensing for Autonomous Vehicles	3	0	0	3
21AL722	Multi Sensor Data Fusion	3	0	0	3
21AL723	Deep Learning and Applications	3	0	0	3

SYLLABUS

EMBEDDED COMPUTING AND PROGRAMMING

21AL601 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce design concepts of embedded systems.

LO2 To provide insights on embedded C programming for configuring microcontroller and peripherals

LO3 To enable development of embedded system models.

Course Outcomes (CO)

CO1 Able to identify the features of STM32F microcontroller.

CO2 Able to apply embedded C programming skills for configuring STM32F peripherals.

CO3 Able to analyze external peripheral interfacing with a microcontroller.

CO4 Able to design and develop embedded systems using STM32F microcontroller.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	-	-	-
CO 2	-	-	3	-	2
CO 3	-	-	3	-	2
CO4	-	-	3	3	2

Skills acquired: Provide detailed insight on configuration and programming of various peripherals in STM32 Microcontroller.

Course Contents

Unit.1: (15 hours)
STM32F Processor: Introduction to Embedded Systems - Introduction to ARM - Advanced RISC Features - Core Data path - Register Organization - System Architecture - Memory Organization - Low Power Modes - Power Control Registers - Backup Registers - Programming STM32F.

Unit.2: (15 hours)
STM32F Peripherals: Introduction to Embedded C Programming - General Purpose Input Output - UART - ADC - DAC - Timers - Interrupts and Exceptions - PWM - SPI.

Unit.3: (15 hours)

External Peripheral Interfacing: LCD - Keypad - Motor - Servo Motor - EEPROM - Seven Segment Interfacing - Sensor Interfacing.

References

1. Muhammad Ali Mazidi, *STM32 Arm Programming for Embedded Systems*, 2019.
2. Donald Norris, *Programming with STM32: Getting Started with the Nucleo Board and C/C++*, McGraw-Hill Education, 2018
3. *STM32F446xx advanced Arm®-based 32-bit MCUs, Reference Manual*, 2020

Evaluation Pattern:

Assessment	Internal	External
Periodical Assessment 1 (P1)	15	NA
Periodical Assessment 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

MACHINE LEARNING AND ALGORITHM DESIGN

21AL602 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the concepts and provide a mathematical foundation for developing machine learning models.
LO2 To provide insights on the evaluation of machine learning models for various applications.
LO3 To impart knowledge on algorithm design and its applications.

Course Outcomes (CO)

CO1 Ability to understand concepts of machine learning and algorithm design.
CO2 Ability to apply machine learning and algorithm design concepts for analysis of problems
CO3 Ability to analyze and process datasets using machine learning techniques for extracting useful information.
CO4 Ability to design and implement machine learning models for the given task

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	2	-	-
CO 2	-	-	2	3	2
CO 3	-	-	2	3	2
CO4	-	-	2	3	3

Skills Acquired: The design and programming ability in machine learning model development for a wide range of industrial applications.

Course Contents

Unit.1: (15 hours)
Mathematical concepts review - Central tendency - Dispersion of data - Descriptive data summaries - k-nearest neighbor classifier - Bayes classifiers - Classifier performance measures.

Unit.2: (15 hours)
Decision tree - Ensemble methods - Ordinary Least Squares - Artificial neurons - Perceptron - Multi Layer Perceptron and backpropagation - Hyperparameter tuning - Cluster analysis - Partitioning methods - Hierarchical methods - Density-based methods - Cluster evaluation.

Unit.3: (15 hours)
Graphs - Definitions and applications - Graph Connectivity - Graph Traversal - Testing Bipartiteness - Breadth-First Search - Directed graphs - Directed Acyclic Graphs -

Topological ordering - Interval scheduling - Optimal caching - Shortest paths - Minimum Spanning Tree - Clustering - Huffman Codes - Data Compression - Partitioning Problems - Graph Coloring.

References

1. Jiawei Han, Micheline Kamber, Jian Pei, *Data Mining: Concepts and Techniques*, 3rd Edition, Morgan Kaufmann Publishers (Elsevier), 2011.
2. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems*, Second Edition, O'Reilly Media, 2019.
3. Earl Gose, Richard Johnsonbaugh, Steve Jost, *Pattern Recognition and Image Analysis*, Pearson Education India, 2015.
4. Jon Kleinberg, Éva Tardos, *Algorithm Design*, Pearson, 2006.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

PRINCIPLES OF AUTOMOTIVE SYSTEMS

21AL611 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the fundamentals vehicle systems.

LO2 To create a complete understanding of the individual systems of a vehicle.

LO3 To impart knowledge of the various basic regulations governing the vehicle safety

Course Outcomes (CO)

CO1 Ability to understand the fundamentals of vehicle systems and regulations.

CO2 Ability to identify various components of a vehicle and explain its functions.

CO3 Ability to gain fundamental knowledge to develop electronic controls for automotive subsystems.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	2	2	3
CO 2	-	-	2	3	-
CO 3	-	-	2	3	3

Skills Acquired: In-depth knowledge of the functioning of various sub systems of an automobile.

Course Contents

Unit.1: (15 hours)

Introduction - Type of vehicles-Overview of testing and homologation standards - Internal combustion engines - Ideal cycles & actual cycles - Reciprocating piston engines - Operating principles - Mixture formation - Combustion - Modes of combustion - Emissions Charge cycle and supercharging/Turbocharging - Exhaust gas recirculation - Air filtration - Engine heat transfer - Test Procedures and Regulation for Engines- Emission Regulations/standards - Emission Measurement and Testing - Other Emission - Particulate - Crankcase - Evaporative - Refueling

Unit.2: (15 hours)

Braking System - Principles, Components - Hydraulic Systems - Drum and Disc Brakes - Suspension System Components and Operation - Front and rear suspension - Steering systems - Columns and Gears - Steering Linkage - Power Assisted Steering Operation - Alignment Principles - Fundamentals of NVH

Unit.3: (15 hours)

Basic Elements of Vehicle and Transmission Engineering - Selecting the Ratios - Overall Gear Ratio - Multi-plate clutches - Matching Engine and Transmission - Passenger Car Transmissions: Manual Passenger Car - Automated Manual Transmissions - Dual Clutch Transmissions - Automatic and Hybrid Drives - Continuously Variable Transmissions

References

1. Heywood J B, *Internal Combustion Engine Fundamentals*, McGraw-Hill, 2011.
2. Colin R. Ferguson, Allan T. Kirkpatrick, *Internal Combustion Engines: Applied Thermosciences*, 3rd Edition, John Wiley and Sons, 2015.
3. Rudolf Limpert, *Brake design and Safety*, SAE Publications, 2015.
4. Heinz Heisler, *Vehicle and Engine Technology*, Butterworth-Heinemann, 2010.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

ELECTRIC VEHICLES AND ARCHITECTURES

21AL612 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce standards, impacts and economy of electric vehicles
LO2 To impart knowledge of electric and hybrid electric vehicle architectures
LO3 To provide an understanding of subsystems in electric and hybrid electric vehicles
LO4 To introduce battery testing, maintenance and monitoring techniques

Course Outcomes (CO)

CO1 Ability to understand standards, impact and economy of Electric Vehicles
CO2 Ability to apply knowledge of vehicle subsystems for electric and hybrid electric configurations
CO3 Ability to analyze the architectures of Electric and Hybrid Electric Vehicles
CO4 Ability to design and simulate electric vehicle subsystems

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	3
CO 2	-	-	3	-	-
CO 3	-	-	3	-	2
CO4	-	-	3	2	2

Skills Acquired: Simulation and analysis of EV, HEV subsystems.

Course Contents

Unit.1: (15 Hours)
Electric vehicles (EVs) - advantages and impacts - EV market and promotion - Infrastructure - Legislation and regulation - Standardization - Energy efficiency - Assessing economy of EVs - Fuel economy - Fuel consumption - Greenhouse gas emissions.

Unit.2: (15 Hours)
Electrical subsystems - Components of a hybrid vehicle - 48V systems - Hybrid vehicle architectures - Design of a Hybrid Electric Vehicle (HEV) -EV architecture - Power converters and motor control - Case studies.

Unit.3: (15 Hours)
Energy storage systems - Batteries and battery parameters - Types and characteristics of EV batteries - Battery testing - Charging schemes - Battery monitoring - Battery load levelling - Energy management strategies – EV Chargers - On-board and off-board chargers.

References

1. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, 2nd Edition, John Wiley and Sons, 2012.
2. John G. Hayes, G. Abas Goodarzi, *Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles*, John Wiley and Sons, 2018.
3. Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer-Verlag New York, 2013.
4. Tom Denton, *Electric and Hybrid Vehicles*, Routledge, 2016.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

DIGITAL CONTROL SYSTEMS

21AL613 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the mathematical concepts for system modeling.

LO2 To impart knowledge of continuous, discrete time and frequency domain techniques

LO3 To provide insights on controller design and its performance.

Course Outcomes (CO)

CO1 Ability to understand the modeling of linear and non-linear electro-mechanical systems.

CO2 Ability to apply continuous, discrete and frequency domain techniques.

CO3 Ability to analyze the stability of linear and non-linear systems in time and frequency domain.

CO4 Ability to design the controllers for satisfying desired closed-loop specifications

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	3
CO 2	-	-	-	2	-
CO 3	-	-	2	2	2
CO4	-	-	3	3	3

Skills Acquired: Modeling and design of control systems, to satisfy the desired performance in industrial applications.

Course Contents

Unit. 1: (15 Hours)

Continuous time systems modeling - Electromechanical systems - Linear and nonlinear systems - System identification - State space analysis - Eigen values - Controllability and observability - Discrete time systems - Discretization of continuous time systems

Unit. 2: (15 Hours)

Discrete time signals - Input output convolution models - Z transform - Inverse Z transforms - Theorems and examples - Stability - Frequency domain analysis - Fourier series - Fourier transforms - Sampling and reconstruction - Filtering - Discrete Fourier transform

Unit. 3: (15 Hours)

Controller design - Control structures - Transfer function - Lead and lag compensators - Proportional controller - Integral - Derivative controller - Comparison - Optimization control - Automotive sub system control using MATLAB - State feedback controller design - Steering control using model predictive controller - Stability and realizability.

References

1. M Gopal, *Digital Control and State Variable Methods*, 4th Ed., McGraw Hill, 2012.
2. Kannan Moudgalya, *Digital Control*, John Wiley & Sons, 2007.
3. Norman S. Nise, *Control Systems Engineering*, 8th Ed., John Wiley & Sons, 2019.
4. Richard C. Dorf, Robert H. Bishop, *Modern Control Systems*, 12th Ed., Pearson, 2010.
5. Katsuhiko Ogata, *Modern Control Engineering*, 5th Ed., Pearson, 2010.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, Seminars and Report

Embedded Systems and Machine Learning Lab

21AL681 **0-0-4-2**

Learning Objectives (LO)

LO1 To provide design concepts on implementation of Embedded Systems
LO2 To provide insight on communication protocols used in embedded domain
LO3 To demonstrate peripheral configuration of a microcontroller platform
LO4 To provide insights into design and implementation of machine learning algorithms

Course Outcomes (CO)

CO1 Ability to interface external peripherals with a programmable platform
CO2 Ability to implement and analyze serial communication protocol
CO3 Ability to design and implement embedded system or machine learning based solutions for a specific application
CO4 Ability to analyze and optimize the performance of the given embedded system/machine learning based system.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	-	2	3	2
CO 2	2	-	2	3	2
CO 3	3	3	3	3	3
CO 4	3	3	2	3	3

Skills Acquired: The programming ability in embedded system design and machine learning model development for a wide range of applications.

Lab Course Contents

Ex. No.	Experiment details
1	General purpose input output configuration and programming
2	LCD and keypad interfacing
3	Universal asynchronous receiver and transmitter (UART) configuration and programming
4	Analog to digital conversion (ADC) peripheral configuration and programming
5	Timer configuration and programming
6	PWM generation and motor speed control
7	Design and implementation of a Bayes classifier for two-class and multi-class classification
8	Design and implementation of an MLP based Artificial Neural Network Model for classification or regression

9	Design and implementation of a deep learning classifier model using transfer learning
10	Design and implementation of a simple DAG Network for deep learning
11	Design and implementation of clustering algorithms
12	Determining the Bipartiteness of a graph using search algorithms

Recommended Tools

STM32CubeMX, Keil µVision, MATLAB, Python

References

1. Muhammad Ali Mazidi, *STM32 Arm Programming for Embedded Systems*, 2019.
2. Donald Norris, *Programming with STM32: Getting Started with the Nucleo Board and C/C++*, McGraw-Hill Education, 2018.
3. *STM32F446xx advanced Arm®-based 32-bit MCUs, Reference Manual*, 2020.
4. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems*, 2nd Edition, O'Reilly Media, 2019.

Evaluation Pattern:

Assessment	Internal	External
*Continuous Assessment (CA)	70	NA
End Semester	NA	30
Total	70	30

*CA – Can be Quizzes, Assignment, Projects, and Report

AUTOMOTIVE SYSTEMS LAB

21AL682 **0-0-4-2**

Learning Objectives (LO)

LO1 To introduce various sub systems of an automobile.
LO2 To introduce environmental noise level measurement for complying with regulations.
LO3 To understand the process of performance analysis of an internal combustion engine.
LO4 To introduce noise measurement techniques for automotive applications.

Course Outcomes (CO)

CO1 Ability to understand basic functioning of power train in an automobile
CO2 Ability to test and calculate the engine parameters
CO3 Ability to understand the noise sources in an automobile
CO4 Ability to identify the various sensors used in an automobile

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	2	2	3	2
CO 2	2	2	1	3	2
CO 3	2	2	3	3	3
CO 4	1	3	2	3	2

Skills Acquired:

The ability to identify various components of an automobile and test its functionality.

Lab Course Contents

Ex. No.	Experiment details
1	Working of Engine and valve timing
2	Steering system, Brake and Transmission systems
3	Sensors used in transmission and engines
4	Performance test on a SI Engine – Fuelled with Gasoline / LPG
5	Heat balance test on Diesel Engine
6	Retardation test on Diesel Engine
7	Environmental Noise measurement
8	Pass-by-Noise measurement and analysis
9	In-Cabin Noise measurement and analysis
10	Exhaust noise measurement in a two-wheeler
11	Exhaust noise measurement in a four-wheeler
12	Noise measurement of a two-wheeler

Recommended Tools

Engine dynamometer, Sound level meter

References

1. Martyr, Anthony J., and Michael Alexander Plint. *Engine testing: The design, building, modification and use of powertrain test facilities*. Elsevier, 2012.
2. Hoag K, Dondlinger B. Vehicular engine design. Springer; 2015.
3. Turner, J. and Watson, J, *Automotive Sensors*, Momentum Press, 2009.
4. Sheng, Gang. *Vehicle Noise, Vibration, and Sound Quality*, SAE International, 2012.

Evaluation Pattern:

Assessment	Internal	External
*Continuous Assessment (CA)	70	NA
End Semester	NA	30
Total	70	30

*CA – Can be Quizzes, Assignment, Projects, and Report

CAREER COMPETENCY I

21HU602 **P/F**

Pre-requisite: An open mind and the urge for self-development, basic English language skills, knowledge of high school level arithmetic.

Course Objective: To help students transit from campus to corporate and assist students in developing soft skills, improve their diction, verbal and non-verbal communication skills and problem-solving skills.

Course Outcomes (CO)

CO1	Soft Skills- By the end of the course, the student will be able to make formal and informal presentations with self confidence
CO2	Soft Skills- By the end of the course, the student will be able to manage time effectively and will be able to set personal goals and achieve them
CO3	Aptitude- By the end of the course the student will be able to critically analyze and evaluate various situations and thus define the problem(s) accurately and then arrive at the best possible solution for the stated/identified problem(s) within the stipulated time constraints.
CO4	Verbal- At the end of the course, the students will have the ability to dissect polysyllabic words, infer the meaning, inspect, classify and use them effectively.
CO5	Verbal- At the end of the course, the students will have the ability to understand the nuances of English grammar and use this knowledge to recognise structural instabilities in sentences.
CO6	Verbal- At the end of the course, the students will have the ability to identify, analyse and interpret relationship between words and use the process of elimination to arrive at the answer. They will also have the ability to use inductive and deductive reasoning to arrive at conclusions and convey their point of view in a convincing manner.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	1	1	2	-	2
CO 2	2	2	1	1	2
CO 3	2	-	1	3	2
CO4	1	3	2	-	2
CO5	1	3	2	-	2
CO6	3	3	2	-	2

Course contents

Soft Skills:

Introduction to ‘campus to corporate transition’:

Communication and listening skills: communication process, barriers to communication, verbal and non-verbal communications, elements of effective communication, listening skills, empathetic listening, role of perception in communication.
Assertiveness skills: the concept, assertiveness and self-esteem, advantages of being assertive, assertiveness and organizational effectiveness.
Self-perception and self-confidence: locus of control (internal v/s external), person perception, social perception, attribution theories-self presentation and impression management, the concept of self and self-confidence, how to develop self-confidence.
Goal setting: the concept, personal values and personal goals, goal setting theory, six areas of goal setting, process of goal setting: SMART goals, how to set personal goals
Time management: the value of time, setting goals/ planning and prioritizing, check the time killing habits, procrastination, tools for time management, rules for time management, strategies for effective time management
Presentation skills: the process of presentation, adult learning principles, preparation and planning, practice, delivery, effective use of voice and body language, effective use of audio visual aids, dos and don'ts of effective presentation
Public speaking-an art, language fluency, the domain expertise (Business GK, Current affairs), self-confidence, the audience, learning principles, body language, energy level and conviction, student presentations in teams of five with debriefing

Aptitude:
Introduction to numbers – number line, classification of numbers, prime and composite numbers, co-prime numbers, number of zeros in an expression, LCM, HCF, remainder theorem, rules of divisibility, base system
Basics of equations- introduction to simple and quadratic equations, roots of an equation, word problems, problems on ages, consistency of equations
Percentages, profit and loss: introduction to percentages, percentage change, value appreciation and depreciation, comparison observations, fundamentals concepts of business/commercial terminologies like cost price, selling price, profit, loss, marked price and discount
Ratio proportion and variation/partnership – fundamentals of ratios, duplicate ratio, triplicate ratio, sub duplicate ratio and sub triplicate ratio, direct and inverse proportion, joint variation, partnership and profit sharing
Averages and mixtures – mean, median and mode, measure of central tendency, concept of assumed average and weighted average, AM, GM and HM – relationship between AM, GM and HM, cheaper quantity and dearer quantity, rule of allegation, profit v/s quality of items getting mixed.
Simple interest and compound interest – time value of money, capital/principle, period of investment, rate of return, period of compounding, SAGR and CAGR
Data interpretation – representation of data using tables, bar charts, pie charts, case study, line graph, scatter diagram – analyzing the data for decision making

Venn diagrams- set theory – concept of sets, types of set, forms of set representation, power set, sub set and super set, 2 and 3 variable venn-diagrams, familiarity with words like AND, OR, atleast, atmost, exactly 'n' elements
Cubes – importance of aligning cuts to minimize/maximize the number of pieces of small cubes, painting a cube and cutting the cube, disintegration and integration of cubes, diagonal cutting, volume/LSA/TSA of cubes

Verbal:
Vocabulary: Familiarize students with the etymology of words, help them realize the relevance of word analysis and enable them to answer synonym and antonym questions. Create an awareness about the frequently misspelt words, commonly confused words and wrong form of words in English.
Grammar: Train students to understand the nuances of English Grammar and thereby enable them to spot grammatical errors and punctuation errors in sentences.
Reasoning: Stress the importance of understanding the relationship between words through analogy questions and learn logical reasoning through syllogism questions.
Oral Communication Skills: Aid students in using the gift of the gab to improve their debating skills.

References

Communication and listening skills:
1. Andrew J DuRbin, "*Applied Psychology: Individual and organizational effectiveness*, Pearson- Merril Prentice Hall, 2004.
2. Michael G Aamodt, *An Applied Approach*, 6th edition, Wadsworth Cengage Learning, 2010.

Assertiveness skills:
3. Robert Bolton, Dorothy Grover Bolton, *People Style at Work..and Beyond: Making Bad Relationships Good and Good*, Ridge Associates Inc., 2009.
4. John Hayes *Interpersonal skills at work*, Routledge, 2003.
5. Nord, W. R., Brief, A. P., Atieh, J. M., & Doherty, E. M., *Meanings of occupational work: A collection of essays (pp. 21- 64)*, Lexington, MA: Lexington Books, 1990.

Self-perception and self-confidence:
6. Mark J Martinko, *Attribution theory: an organizational perspective*, St. Lucie, 1995.
7. Miles Hewstone, *Attribution Theory: Social and Functional Extensions*, Blackwell, 1983.

Time management:
8. Stephen Covey, *The habits of highly effective people*, Free press Revised Ed., 2004.
9. Kenneth H Blanchard, *The 25 Best Time Management Tools & Techniques: How to Get More Done Without Driving Yourself Crazy*, Peak Performance Press, 1st Ed. 2005.
10. Kenneth H. Blanchard and Spencer Johnson, *The One Minute Manager* , William Morrow, 1984.

Aptitude:

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12. Arun Sharma, *How to Prepare for Logical Reasoning for the CAT Common Admission Test*, Tata Mc Graw Hill, 2nd Edition, 2014.
13. Arun Sharma, *How to Prepare for Data Interpretation for the CAT Common Admission Test*, Tata Mc Graw Hill, 3rd Edition, 2015.
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15. R.S. Aggarwal, *A Modern Approach to Verbal & Non-Verbal Reasoning*, S. Chand Publishing, 2015.
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Verbal:

20. Lewis Norman, *Word Power Made Easy*, Goyal Publishers, Reprint edition, 2011.
21. S. Upendran, *Know Your English*, Universities Press (India) Limited, 2015.
22. Green, Sharon, Ira K. Wolf, *Barron's New GRE*, Barron's Educational Series, 2011.
23. Kaplan, *New GMAT Premier*, Kaplan Publishing, U.K., 2013.
24. www.merriam-webster.com
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Evaluation Pattern:

Assessment	Internal	External
*Continuous Assessment (CA)- Soft Skills	40	NA
*Continuous Assessment (CA)- Aptitude Skills	30	NA
*Continuous Assessment (CA)- Verbal Skills	30	NA
Total	100	NA

*CA - Can be Presentations, Assignments, Speaking activities and tests.

VEHICLE DYNAMICS AND CONTROL

21AL614 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the fundamentals of automated highway systems and driver assistance systems.

LO2 To create a complete understanding of various forces acting on the vehicle during acceleration and cornering and design various systems to control them.

LO3 To understand the generation of lateral force during cornering and design and develop a control system

Course Outcomes (CO)

CO1 Ability to understand the fundamentals vehicle dynamics

CO2 Ability to identify various forces and control them during acceleration and braking

CO3 Ability to gain fundamental knowledge of force generation during cornering

CO4 Ability to develop a control system for reducing the effect of lateral forces

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	2	-	-
CO 2	1	-	2	3	2
CO 3	-	-	2	3	2
CO4	1	-	2	3	3

Skills Acquired: Ability to understand the generation of various forces in a vehicle and design a control system to reduce their effect.

Course Contents

Unit.1: (15 hours)

Introduction - Automated highway system and driver assistance systems- Longitudinal vehicle control – Introduction - Longitudinal vehicle model - From body fixed to global coordinates - Driveline dynamics - Mean value engine models - Anti-lock braking system and control system design - Cruise control - Adaptive Cruise Control (ACC) - Control system architecture for ACC - Controller for transitional maneuvers - Overview.

Unit.2: (15 hours)

Lateral vehicle dynamics - Kinematic models - Dynamic bicycle model - Lateral vehicle control- State feedback - Steady state analysis - Understanding steady state cornering - The output feedback problem - Compensator design with look ahead measurement - Active stability control - Ride quality.

Unit.3: (15 hours)

Electronic stability control - Vehicle model - Control design for differential braking based systems - Control design for steer–by–wire systems - Independent all-wheel drive torque control - Active automotive suspensions - Semi–active automotive suspensions - Rollover prevention control - Rollover dynamics - Rollover index and active rollover prevention - Comparison of performance with various rollover indices - Rollover in passenger cars and heavy commercial vehicles with trailers.

References

1. R. Rajamani, *Vehicle Dynamics and Control*, Second Edition, Springer Verlag, 2012.
2. Hans B. Pacejka, *Tyre and Vehicle Dynamics*, Third Edition, Butterworth–Heinemann, 2012.
3. Thomas D. Gillespie, *Fundamentals of Vehicle Dynamics*, SAE International, 1992.
4. Uwe Kiencke and Lars Nielsen, *Automotive Control Systems: For Engine, Driveline, and Vehicle*, Second Edition, Springer, 2005.
5. John C. Dixon, *Tyres, Suspension and Handling*, Second Revised Edition, SAE International, 1996.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

RTOS FOR MULTICORE ENVIRONMENT

21AL615 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce concepts of Real Time Operating Systems.

LO2 To provide insights on Microarchitecture design for Microprocessors.

LO3 To provide insights on Programming Models for Multicore Architectures.

Course Outcomes (CO)

CO1 Ability to understand the features of Real Time Operating Systems.

CO2 Ability to evaluate the performance of real-time systems.

CO3 Ability to analyze the architectural design of Microprocessors.

CO4 Ability to analyze Programming Models for Multicore Systems.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	2
CO 2	-	-	3	-	2
CO 3	-	-	3	-	2
CO4	-	-	3	-	2

Skills acquired: Detailed insight on architectural design of a Multicore System.

Course Contents

Unit.1: (15 Hours)

Real Time Operating System- Introduction to real-time systems - Characteristics and Classification of real-time systems - Features to Real-time Operating Systems - Event and Time Triggered Systems - Tasks and Task States - Processor Utilization Factor - Rate Monotonic, Deadline Monotonic and Earliest Deadline First Scheduling - Response Time Analysis - Processor Demand Analysis - Blocking - Priority Inversion - Priority Inheritance - Priority Ceiling Protocol - Response Time Analysis with Blocking

Unit.2: (15 Hours)

Microarchitecture for Multicore- Single-Cycle Processor - Single-Cycle Datapath - Single-Cycle Control - Performance Analysis - Multicycle Processor - Multicycle Datapath - Multicycle Control - Pipelined Processor - Pipelined Datapath - Pipelined Control - Hazards - Advanced Microarchitecture - Deep Pipelines - Micro-Operations - Branch Prediction - Superscalar Processor - Out-of-Order Processor - Register Renaming - Multithreading - Multiprocessors.

Unit.3: (15 Hours)

Programming Multicore Architectures - Memory Models - Memory structure of multicore architecture - Cache coherency - Transactional memory - System Virtualization - Hypervisor architectures - Leveraging hardware assists for virtualization - I/O Virtualization - Programming Models for MultiCore - Hybrid Programming with OmpSs - Introduction to AUTOSAR – Layered Software Architecture – Software Components and Ports.

References

1. Sarah L. Harri, David Money Harris, *Digital Design and Computer Architecture*: *ARM Edition*, Elsevier Inc, 2016.
2. Sabri Pllana, Fatos Xhafa, *Programming Multicore and Many-core Computing Systems*, Wiley, 2017.
3. Donald Norris, *Real World Multicore Embedded Systems*, Elsevier Inc, 2013
4. Hans Hansson, Jan Carlson, Damir Isovic, Kristina Lundqvist, Thomas Nolte, Martin Ouimet , Paul Pettersson, Sasikumar Punnekkat, Cristina Seceleanu, *Real-Time Systems*, Fraunhofer IESE, 2010.
5. AUTOSAR Layered Software Architecture, AUTOSAR, 2017.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

AUTOMOTIVE TESTING LAB

21AL683 **0-0-4-2**

Learning Objectives (LO)

LO1 To understand various testing methods to check the performance of various automotive subsystems.

LO2 To understand various vibration measurement processes in an automobile.

LO3 To introduce the processes for carrying out performance and emission tests on an automobile.

LO4 To diagnose the vehicle using an OBD tool

Course Outcomes (CO)

CO1 Ability to understand engine testing cycles

CO2 Ability to understand various emission parameters of petrol and diesel engine

CO3 Ability to identify the various vibration sources in an automobile.

CO4 Ability to diagnose the fault of an automobile using OBD tool

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	-	2	-	2
CO 2	2	3	2	2	2
CO 3	3	2	3	3	3
CO 4	2	-	2	-	2

Skills Acquired:

The ability to perform various test cycles in the chassis dyno, engine dyno and vibration measurement for various sub systems.

Course Contents

Ex. No.	Experiment details
1	Indian Driving cycle – Chassis dyno
2	Performance and emission test – 8 mode
3	Performance and emission test – 13 mode
4	Assess the Performance of Biofuel on engines
5	Assess the performance of Multiple coolant types on engines
6	On board diagnostics of Engine faults
7	On board diagnostics of transmission faults
8	Vibration measurement in Engines
9	Vibration measurement in Vehicles
10	Transfer path analysis
11	Binaural recording for sound quality studies
12	Psycho Acoustic Analysis

Recommended Tools

Chassis dynamometer, Engine dynamometer, Emission analyser, Head Measurement system, Listening studio

References

1. Grubinger-Rhodes, C., and Klingenberg, H, *Automobile Exhaust Emission Testing: Measurement of Regulated and Unregulated Exhaust Gas Components, Exhaust Emission Tests*, Springer Berlin Heidelberg, 2012.
2. Christian U. Grosse and Masayasu Ohtsu Eds, *Acoustic Emission Testing*, Springer Berlin Heidelberg, 2008.
3. Hiroshi Nakamura, Masayuki Adachi, *Engine Emissions Measurement Handbook: HORIBA Automotive Test Systems*, SAE International, 2014.
4. Evangelos G Giakoumis, *Driving and Engine Cycles*, Springer International Publishing, 2016.
5. Gang Sheng, *Vehicle Noise, Vibration, and Sound Quality*, SAE International, 2012.

Evaluation Pattern:

Assessment	Internal	External
*Continuous Assessment (CA)	70	NA
End Semester	NA	30
Total	70	30

*CA – Can be Quizzes, Assignment, Projects, and Report

AUTOMOTIVE CONTROL AND VEHICLE SIMULATION LAB

21AL684 **0-0-4-2**

Learning Objectives (LO)

LO1 To understand the modeling of linear and non-linear electro-mechanical systems.

LO2 To analyze the system stability and controllers tracking and robust performance in presence of parameter uncertainty and external disturbances

LO3 To design and validate the controller's performance.

Course Outcomes (CO)

CO1 Ability to model the linear and non-linear, electro-mechanical system dynamics

CO2 Ability to analyze the system stability and performance

CO3 Ability to design controllers for satisfying the desired closed-loop performance.

CO4 Ability to analyze vehicle behavior under various conditions.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	-	2	-	2
CO 2	2	3	2	2	2
CO 3	3	2	3	3	3
CO 4	2	-	2	-	2

Skills Acquired:

Modeling, design of control systems, and its implementation to satisfy the desired performance in a wide range of industrial applications.

Lab Course Contents

Ex. No.	Experiment details
1	Modeling active suspension system and stability analysis with disturbance input
2	Design and implementation of P, PI and PID controllers for a Non-linear system
3	Steering control using model predictive controller
4	Tracking and robust control performance of different controllers in presence of parameter uncertainty and external disturbances.
5	Vehicle model creation and track definition
6	Defining driver maneuvers, parameter plotting
7	Brake testing
8	Acceleration testing
9	Single lane change testing
10	Double lane change testing
11	Slalom testing

Recommended Tools

IPG carmaker, MATLAB Simulink, Arduino microcontroller

References

1. Katsuhiko Ogata, *Modern Control Engineering*, 5th Ed, Pearson, 2010.
2. Norman S. Nise, *Control Systems Engineering*, 6th Ed, John Wiley & Sons, 2011.
3. IPG carmaker user manual

Evaluation Pattern:

Assessment	Internal	External
*Continuous Assessment (CA)	70	NA
End Semester	NA	30
Total	70	30

*CA – Can be Quizzes, Assignment, Projects, and Report

RESEARCH METHODOLOGY

21RM601 **2-0-0-2**

Learning Objectives (LO)

LO1 To enable defining and formulating research approaches towards obtaining solutions to practical problems.

LO2 To facilitate development of scientific oral and written communication skills.

LO3 To comprehend the concepts behind adhering to scientific ethics and values.

Course Outcomes (CO)

CO1 Ability to understand some basic concepts of research and its methodologies.

CO2 Ability to define and apply appropriate parameters and research problems.

CO3 Ability to develop skills to draft a research paper.

CO4 Ability to analyse and comprehend the ethical practices in conducting research and dissemination of results in different forms.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	2	3	-	2
CO 2	2	2	2	-	2
CO 3	3	2	3	-	3
CO4	3	2	2	3	3

Skills Acquired: Design, analyse and conduct research and comprehend the results.

Course Contents

Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach, Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of reasoning in research.

Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science

References

1. Bordens, K. S. and Abbott, B. B., *Research Design and Methods – A Process Approach*, 8th Edition, McGraw-Hill, 2011.
2. C. R. Kothari, *Research Methodology – Methods and Techniques*, 2nd Edition, New Age International Publishers.
3. Davis, M., Davis K., and Dunagan M., *Scientific Papers and Presentations*, 3rd Edition, Elsevier Inc.
4. Michael P. Marder, *Research Methods for Science*, Cambridge University Press, 2011.
5. T. Ramappa, *Intellectual Property Rights Under WTO*, S. Chand, 2008.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, *Intellectual Property in New Technological Age*, Aspen Law & Business, 6th Edition July 2012.
7. Tony Greenfield and Sue Greener, *Research Methods for Postgraduates*, 3rd Edition, John Wiley & Sons Ltd., 2016.

Evaluation Pattern:

Assessment	Internal	External
Periodical Assessment (P)	20	NA
*Continuous Assessment (CA)	30	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, Seminars and Report

CAREER COMPETENCY II

21HU603 **0-0-2-1**

Pre-requisite: Willingness to learn, team spirit, basic English language and communication skills, knowledge of high school level arithmetic.

Course Objective: To help students understand the importance of working in teams, to demonstrate interpersonal skills, communication skills, reasoning skills and problem-solving skills. And also, to prepare them for effective group discussions and interviews participation.

Course Outcomes (CO)

CO1 Soft Skills- By the end of the course, the student will be able to participate and effectively contribute in group discussions

CO2 Soft Skills- By the end of the course, the student will be able to interact effectively in formal and informal interview situations

CO3 Aptitude- By the end of the course, the student will be able to demonstrate various principles involved in problem solving and thereby reducing the time taken for performing job functions without compromising on the quality and cost aspects.

CO4 Verbal- At the end of the course, the students will have the ability to relate, choose, conclude and determine the usage of right vocabulary and understand the usage of idioms and phrasal verbs.

CO5 Verbal- At the end of the course, the students will have the ability to decide, identify, conclude and choose the right grammatical construction.

CO6 Verbal- At the end of the course, the students will have the ability to comprehend, interpret, deduce and logically connect words, phrases and sentences. They will also have the ability to examine, interpret and investigate arguments and confidently express their opinion to the audience/recipient using their communication skills in English.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	1	2	1	2
CO 2	2	2	2	1	2
CO 3	2	1	2	2	2
CO4	-	3	2	-	2
CO5	1	3	2	-	2
C06	2	3	2	-	2

Course contents

Soft Skills*:

Interpersonal skill: ability to manage conflict, flexibility, empathetic listening, assertiveness, stress management, problem solving, understanding one's own interpersonal needs, role of effective teamwork in organizations

Group problem solving: the process, the challenges, the skills and knowledge required for the same.

Conflict management: the concept, its impact and importance in personal and professional lives, (activity to identify personal style of conflict management, developing insights that helps in future conflict management situations.)

Team building and working effectively in teams: the concept of groups (teams), different stages of group formation, process of team building, group dynamics, characteristics of effective team, role of leadership in team effectiveness. (Exercise to demonstrate the process of emergence of leadership in a group, debrief and reflection), group discussions.

Interview skills: what is the purpose of a job interview, types of job interviews, how to prepare for an interview, dos and don'ts of interview, One on one mock interview sessions with each student

* Specific Technical Skills/ proficiency in programming skills

Aptitude:

Time and distance: speed, distance, displacement, relative speed, average speed, races, boats and streams-upstream and down-stream movement, problems on trains, concept of relative speed, motion in circular track – clockwise and anti-clockwise rotations

Time and work- unitary method, concept of man-days, efficiency in task completion, sharing of wages proportionately, questions on pipes and cisterns

Geometry, mensuration-line/ray/angles, length of segments, area and properties of geometrical figures, properties of angles, diagonals, LSA, TSA and volume of solids

Seating arrangements/ puzzles- linear arrangements, circular arrangements, selection, comparison and distribution of objects under given constraints, analysing given constraints and present definitive or probable solutions for a given problem.

Permutations and combinations- fundamental principle of counting-selection and arrangement of objects, factorial notations, permutations with/without repetition, rank of a word, sum of all permutations, team formation with certain constraints

Probability- chances, odds in favour and odds against favour, events-independent and mutually exclusive types, conditional probability

Nonverbal reasoning – picture-based series, mirror image, water image, paper folding, paper cutting, grouping of figures, figure matrix

Quant Based Reasoning – case study, application-oriented problems

Verbal:

Vocabulary: Help students understand the usage of words in different contexts. Stress the importance of using refined language through idioms and phrasal verbs.

Grammar: Enable students to identify poorly constructed sentences or incorrect sentences and improvise or correct them.
Reasoning: Facilitate the student to tap her/his reasoning skills through critical reasoning questions and logical ordering of sentences.
Reading Comprehension: Enlighten students on the different strategies involved in tackling reading comprehension questions.
Public Speaking Skills: Empower students to overcome glossophobia and speak effectively and confidently before an audience.
Writing Skills: Introduce formal written communication and keep the students informed about the etiquettes of email writing.

References

Team Building

1. Thomas L. Quick, *Successful team building*, AMACOM, 1992
2. Brian Cole Miller, *Quick Team-Building Activities for Busy Managers: 50 Exercises That Get Results in Just 15 Minutes*, AMACOM; 1st Edition, 2003.
3. Patrick Lencioni, *The Five Dysfunctions of a Team: A Leadership Fable*, Jossey-Bass, 1st Edition, 2002

Aptitude

4. Arun Sharma, *How to Prepare for Quantitative Aptitude for the CAT Common Admission Test*, Tata McGraw Hill, 5th Edition, 2012.
5. Arun Sharma, *How to Prepare for Logical Reasoning for the CAT Common Admission Test*, Tata McGraw Hill, 2nd Edition, 2014.
6. Arun Sharma, *How to Prepare for Data Interpretation for the CAT Common Admission Test*, Tata McGraw Hill, 3rd Edition, 2015.
7. R.S. Aggarwal, *Quantitative Aptitude for Competitive Examinations*, S. Chand Publishing, 2015.
8. R.S. Aggarwal, *A Modern Approach to Verbal & Non-Verbal Reasoning*, S. Chand Publishing, Revised, 2015.
9. Sarvesh Verma, *Quantitative Aptitude-Quantum CAT*, Arihant Publications, 2016.
10. www.mbatious.com
11. www.campusgate.co.in
12. www.careerbless.com

Verbal

13. P. C. Wren and H. Martin, *English Grammar & Composition*, S. Chand Publishing, 2019
14. Jeff Kolby, Scott Thornburg and Kathleen Pierce, *Nova's GRE Prep Course*, Prakash Books India Pvt. Ltd, 2017
15. Kaplan Test Prep, *GRE Comprehensive Programme*, Kaplan Publishing, 2009.

16. R.S. Aggarwal, *A Modern Approach to Verbal Reasoning*, S. Chand Publishing, 2015.
17. Kaplan, *Kaplan New GMAT 2012-2013 Premier*, Kaplan Publishing, 2012.
18. www.campusgate.co.in
19. www.indiabix.com
20. www.bristol.ac.uk/arts/skills/grammar/grammar_tutorial/page_55.htm

Evaluation Pattern:

Assessment	Internal	External
*Continuous Assessment (CA)- Soft Skills	40	NA
*Continuous Assessment (CA)- Aptitude Skills	10	NA
*Continuous Assessment (CA)- Verbal Skills	10	NA
End Semester Exam	NA	40
Total	60	40

*CA - Can be Presentations, Assignments, Speaking activities and tests.

21XXXXX/21LIV601 OPEN LAB / LIVE-IN LAB

0-0-4-2

Learning Objectives (LO)

LO1 To enable the students to acquire independent research aptitude.
LO2 To provide a platform to utilize the existing facilities / tools to address socially relevant problems.
LO3 To facilitate the design and development of a proof-of-concept system.

Course Outcomes (CO)

CO1 Ability to understand the research needs to address practical problems.
CO2 Ability to define and apply relevant concepts to the research problem.
CO3 Ability to develop a proof-of-concept system.
CO4 Ability to evaluate and analyse the results for further improvement.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2	-	3	-	3
CO 2	2	-	3	-	3
CO 3	2	3	3	3	-
CO4	2	3	3	3	-

Skills Acquired:

- Ability to understand the research needs.
- Develop a meaningful proof of concept system.

Course Contents

Design and development of a proof-of-concept system for the chosen problem.

Evaluation Pattern:

Assessment	Internal	External
*Continuous Assessment (CA)	70	NA
End Semester	NA	30
Total	70	30

*CA – Can be Quizzes, Assignment, Projects, and Report

DISSERTATION PHASE-I

21AL798 **0-0-20-10**

Learning Objectives (LO)

LO1 To impart knowledge of computational and electronic concepts in automotive electronic systems.
LO2 To provide a platform for innovations in automotive electronic systems.
LO3 To facilitate the identification of the state-of-the-art research challenges automotive electronic systems.

Course Outcomes (CO)

CO1 Ability to define a research problem.
CO2 Ability to apply mathematical concepts to the research problem.
CO3 Ability to design and conduct independent research in the domain of interest.
CO4 Ability to evaluate and analyze the outcomes of the research.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	3	-	-
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO4	3	3	3	-	3

Skills Acquired:

- Design and perform independent research.
- Evaluate and analyze the outcomes of the research.

Course Contents:

Problems and concepts may be defined based on extensive literature survey by standard research articles - Significance of proposed problem and the state-of the art to be explored - Industry relevant tools may be used for demonstrating the results with physical meaning and create necessary research components - Publications in reputed journals and conferences may be considered for authenticating the results.

Evaluation Pattern:

Assessment	Internal	External
*Continuous Assessment (CA)	70	NA
End Semester	NA	30
Total	70	30

*CA – Can be Periodical Reviews, Demonstrations and Reports

DISSERTATION PHASE-II

21AL799 **0-0-28-14**

Learning Objectives (LO)

LO1 To impart knowledge of computational and electronic concepts in automotive electronic systems.
LO2 To provide a platform for innovations in automotive electronic systems.
LO3 To facilitate the identification of the state-of-the-art research challenges automotive electronic systems.

Course Outcomes (CO)

CO1 Ability to define a research problem.
CO2 Ability to apply mathematical concepts to the research problem.
CO3 Ability to design and conduct independent research in the domain of interest.
CO4 Ability to evaluate and analyze the outcomes of the research.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	3	3	3	-	-
CO 2	3	3	3	3	3
CO 3	3	3	3	3	3
CO4	3	3	3	-	3

Skills Acquired:

- Design and perform independent research.
- Evaluate and analyze the outcomes of the research.

Course Contents:

Problems and concepts may be defined based on extensive literature survey by standard research articles - Significance of proposed problem and the state-of the art to be explored - Industry relevant tools may be used for demonstrating the results with physical meaning and create necessary research components - Publications in reputed journals and conferences may be considered for authenticating the results.

Evaluation Pattern:

Assessment	Internal	External
*Continuous Assessment (CA)	70	NA
End Semester	NA	30
Total	70	30

*CA – Can be Periodical Reviews, Demonstrations and Reports

Electives

VEHICULAR COMMUNICATION

21AL701 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce emerging technologies in vehicular communication systems and networks.

LO2 To provide insights on challenges and design considerations of V2X communications at various networking layers.

LO3 To impart knowledge on various aspects of a vehicular communication network.

Course Outcomes (CO)

CO1 Ability to understand technologies, standards and system architecture of vehicular networks.

CO2 Ability to analyze vehicular communication technologies for safety and infotainment applications.

CO3 Ability to implement vehicular communication networks using simulation Tools.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	3
CO 2	-	-	3	-	3
CO 3	-	-	3	3	3

Skills Acquired: Analysis and design of vehicular communication networks models for vehicular applications.

Course Contents

Unit.1: (15 Hours)

Applications of V2X-safety vs. non-safety-use cases - Service requirements of applications - Communication technologies - Mapping service requirements to communication technologies - Fundamental principles of layering - DSRC/WAVE- ETSI ITS-G5 and ARIB architectures - DSRC standard-channelization - SAE J2735 message set dictionary - Basic Safety Message - Introduction to IEEE 1609.2-2016 - IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Applications and Management Messages - Introduction to IEEE 802.11p MAC and PHY layers - Introduction to Cellular V2X for connected cards – standards - spectrum and channels - radio interfaces – applications.

Unit.2: (15 Hours)

Wireless radio propagation and channel characteristics – pathloss - shadowing and small - scale fading - delay spread and Doppler spread - coherence bandwidth and coherence time - impact of channel impairments on system design - Techniques for combating channel impairments - Digital modulation schemes in 802.11p - Design of OFDM parameters in 802.11p - Transmit power control and transmit masks.

Unit.3: (15 Hours)

Routing in VANETs - flooding and the Broadcast Storm Problem - Traditional MANET routing- topology based / table-driven routing protocols - proactive (DSDV) vs. reactive / on-demand (DSR - AODV- DYMO) routing protocols - Geographic routing protocols- Beaconing - DTN and peer-to-peer ideas for VANET routing - Vehicular communication simulations (VEINS, OMNET++, SUMO, SimuLTE) - mobility models - traffic flow models.

References

1. Mikael Fallgren, Markus Dillinger, Toktam Mahmoodi, Tommy Svensson, *Cellular V2X for Connected Automated Driving*, Wiley, 2021.
2. Christophe Sommer and Falko Dressler, *Vehicular Networking*, Cambridge University Press, 2014.
3. Hannes Hartenstein and Kenneth Laberteaux (eds.), *VANET Vehicular Applications and Inter-networking Technologies*, John Wiley & Sons, 2009.
4. Claudia Campolo, Antonella Molinaro and Riccardo Scopigno, *Vehicular ad hoc Networks: Standards, Solutions, and Research*, Springer, 2015.
5. Radu Popescu-Zeletin, Ilja Radusch, Mihai Adrian Rigani, *Vehicular-2-X Communication - State-of-the-Art and Research in Mobile Vehicular Ad hoc Networks*, Springer, 2010.
6. Theodore S. Rappaport, *Wireless Communications: Principles and Practice*, Second Edition, Prentice Hall, 2001.
7. Andrea Goldsmith, *Wireless Communications*, Cambridge University Press, 2005.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

VEHICULAR NETWORKS

21AL702 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce various communication protocols used in automotive applications
LO2 To impart knowledge on CAN-FD and LIN based communication protocols with suitable hardware.
LO3 To provide insights on architecture and implementation of vehicular networks .

Course Outcomes (CO)

CO1 Ability to understand vehicular networking architectures CAN-FD, CAN security
CO2 Ability to understand the architecture of LIN and MOST communication protocol.
CO3 Ability to evaluate vehicular networking architectures using simulation tools

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	2	-	2
CO 2	-	-	2	-	2
CO 3	-	-	2	3	2

Skills Acquired: Implementation of different vehicular communication protocols.

Course Contents

Unit.1: (15 Hours)

In-Vehicle Communication Networks - Historical Perspective and Review - CANFD Protocol-Overview of CANFD bus architecture - Physical Layer - Topology - frame architecture - CAN vs CANFD - Bit stuffing and CRC - Delay compensation - Error Handling - Instrument Cluster Simulator (ICSim) for SocketCAN - Car loop Simulator, Virtual CAN Network - CAN Developer Studio - Virtual ECU tools - Introduction to CAN bus security and simulations

Unit.2: (15 Hours)

LIN Protocol - Overview - Frame Format - Bus Timing - Topology - Error detection - Sleep/Wake-up modes - Advanced Frames

Unit.3: (15 Hours)

MOST Protocol-Overview - Physical Layer - Network and Fault Management - Diagnostics - Interface Controller - Applications - Overview of Automotive Ethernet protocols- Introduction to Service Oriented Architecture for automotive industry

References

1.Richard Zurawski, *Industrial Communication Technology Handbook*, 2nd Edition, CRC Press, 2014.

2. Thomas Königseder and Kirsten Matheus, *Automotive Ethernet*, 3rd Edition, Cambridge University Press, 2021.
3. Gilbert Held, *Inter- and Intra-Vehicle Communications*, Auerbach Publications, 2007.
4. Dominique Paret, Roderick Riesco, *Multiplexed Networks for Embedded Systems: CAN, LIN, FlexRay, Safe-by-Wire*, John Wiley and Sons, 2007.
5. Andreas Grzemba, *MOST- The Automotive Multimedia Handbook*, Franzis Verlag GmbH, 2011.
6. Olaf Pfeiffer, *Implementing Scalable CAN Security with CANcrypt Authentication and encryption for the Controller Area Network (CANcrypt)*, Embedded Systems Academy GMBH, 2017.
7. Wilfried Voss, *Controller Area Network Prototyping with Arduino*, Copperhill Technologies Corporation, 2014.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

CRYPTOGRAPHY AND NETWORK SECURITY

21AL703 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the fundamental principles of cryptography and security.
LO2 To provide a strong mathematical foundation for cryptography and security.
LO3 To impart an understanding of the security mechanisms currently used in practice at various networking layers.

Course Outcomes (CO)

CO1 Ability to understand the fundamental principles behind cryptography and security
CO2 Ability to apply the concepts of public key cryptography for different use cases.
CO3 Ability to analyse various protocols for network security.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	-	-	2	2	3
CO2	-	-	2	2	3
CO3	-	-	2	3	3

Skills Acquired

1. To design and analyse new cryptographic algorithms.
2. Acquire background on well-known network security protocols to protect against the threats in the networks.

Course Contents

Unit.1: (15 Hours)
Network security concepts - Introduction to Number Theory - Classical encryption techniques - Block ciphers - Data Encryption Standard (DES) - Finite fields - Advanced Encryption Standard (AES) - Stream ciphers.

Unit.2: (15 Hours)
Asymmetric ciphers - Public-key cryptography - Rivest-Shamir - Adleman (RSA) scheme- Elliptic curve cryptography - Cryptographic Data Integrity Algorithms- Hash functions- Message Authentication Codes (MAC)- Digital signatures - PKI, Mutual Trust - Key management and distribution - User authentication.

Unit.3: (15 Hours)
Network Security - Network Access Control and authentication protocols - Transport-level security - Wireless network security - IP security - Security and privacy - preserving mechanisms in vehicular networks.

References

1. William Stallings, *Cryptography and Network Security*, 7th Ed., Pearson, 2017.

2. Xiaodong Lin, Rongxing Lu, *Vehicular Ad Hoc Network Security and Privacy*, Wiley, 2015.
3. David Forster, *Verifiable Privacy Protection for Vehicular Communication Systems*, Springer, 2017.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

POWER CONVERTERS FOR AUTOMOTIVE APPLICATIONS

21AL711 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the Power electronic devices, their *i-v* characteristics, and their data sheet interpretations.

LO2 To impart knowledge of ac-dc, dc-dc and dc-ac converters with emphasize on various automotive applications.

LO3 To provide insight on control of various power converter circuits.

Course Outcomes (CO)

CO1 Ability to understand various power semiconductor devices, converters and their performance analysis.

CO2 Ability to design various Power electronic converters and their auxiliary elements for automotive applications.

CO3 Ability to develop controls for ac-dc, dc-dc and dc-ac converters for automotive applications.

CO4 Ability to evaluate the performance of various power electronic converters.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	2	2
CO 2	-	-	3	-	3
CO 3	-	-	2	2	2
CO4	-	-	2	2	2

Skills Acquired: Analysis and Design of power electronic converters for EV applications.

Course Contents

Unit 1: (15 Hours)

Overview of power semiconductor switches - *i-v* and switching characteristics of Power BJT - Thyristors - Power Diodes – MOSFET - IGBT - IGCT - Intelligent Power Modules (IPM) - Introduction to Wide band gap power semiconductor devices - Evaluation of Losses in Semiconductor switches- Interpretation of device data sheets - Power Computations for Non-sinusoidal Periodic Waveforms. AC-DC converters - Uncontrolled rectifiers - single and three phase - Performance parameters.

Unit 2: (15 Hours)

DC/DC converters for automotive applications - Design and analysis of Buck-Boost - Four quadrant dc-dc converter - Control of DC-DC converters - Low voltage electrical loads in EV and Auxiliary Power Modules - Converter Topologies for Auxiliary Power Modules - fly-back - forward - push-pull - Full bridge - bidirectional DC-DC converters for EV charging applications - Typical specifications of power converters - design of power circuit to meet the specifications.

Unit 3: (15 Hours)

DC/AC converters - Voltage source inverters- single and three phase Sinusoidal PWM and Space vector PWM - DC side current of PWM inverter - Current regulated PWM - Rectifier and inverter Mode of operation - G2V and V2G operation in EVs - Introduction to Multilevel inverters - Design of Heat sinks - Snubber circuits and driver circuits - Magnetic Design- Energy Storage Requirements for EV - Battery Management Systems - Simulation tools for power converters - Relevant Automotive Standards - Automotive Design Considerations - Power conditioning in power converters - High temperature applications.

References

1. Emadi, Ali, *Advanced Electric Drive Vehicles*, CRC Press, 2014.
2. Muhammad H. Rashid, *Power Electronics, Circuits, Devices and Applications*, Fourth Edition, Pearson, 2014.
3. Randall Shaffer, *Fundamentals of Power Electronics with MATLAB*, Firewall Media, 2013.
4. Wengang Wayne Bi, Haochung Henry Kuo, Peicheng Ku, and Bo Shen, eds., *Handbook of GaN Semiconductor Materials and Devices*, CRC Press, 2017.
5. Daniel Hart, *Power Electronics*, McGraw-Hill, 2011.
6. Ned Mohan, Tore M. Undeland and William P.Robbins, *Power Electronics, Converters, Applications and Design*, Third Edition, John Wiley and Sons Inc., 2006.
7. John G. Kassakian, Martin F.Schlecht and George C.Verghese, *Principles of Power Electronics*, Addison Wesley, 1991.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects and Report

ELECTRICAL MACHINES FOR AUTOMOTIVE APPLICATIONS

21AL712 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the basic principles of electromechanical energy conversion
LO2 To introduce mathematical model of DC and AC Machines for transient and steady state conditions
LO3 To impart knowledge on dynamic behavior of AC& DC machines using Simulation Tools
LO4 To provide insight on principle and working of typical machines used in Automotive Applications.

Course Outcomes (CO)

CO1 Ability to understand the basic principles of electro-mechanical energy.
CO2 Ability to apply reference frame theory to AC machines.
CO3 Ability to analyse behavior of typical machines used in Automotive Applications
CO4 Ability to evaluate the dynamic performance of AC& DC machines
CO5 Ability to create the mathematical model of DC and AC Machines for transient and steady state conditions

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	-
CO 2	-	-	3	2	-
CO 3	-	-	3	2	2
CO4	-	-	3	2	2
CO5	-	-	3	-	-

Skills Acquired: Provide a practical approach for Performance Analysis of DC, AC and typical machines used in Automotive Applications using MATLAB/Simulink.

Course Contents

Unit.1: (15 hours)

Review of Electromagnetics - Principles of electromagnetic energy conversion-DC Machines - Basics - Performance Analysis - Generalized theory of rotating electrical machines - Modeling- Steady state and transient analysis of separately excited DC machines - Analysis with Simulation tools.

Unit.2: (15 hours)

AC Machines – Basics - Performance Analysis - Transformations in AC machine analysis - Introduction to reference frame theory - Application of reference frame theory to three phase symmetrical induction machines - Modeling - Torque calculation - Steady state and transient analysis of induction machines.

Unit.3: (15 hours)

Synchronous Machine Analysis - Steady state and transient behavior of synchronous machines - Typical Machines used in Automotive Applications - Permanent Magnet Machine - Switched Reluctance Machine - Principle of working - Steady state operation- Analysis with Simulation tools.

References

1. P.C.Krause, *Analysis of Electric Machines and Drive Systems*, Wiley International, 2013.
2. B. Adkins, *Generalized Machine Theory*, McGraw-Hill, 1964.
3. Ramu Krishnan, *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Press, 2017
4. T.A.Lipo, *Analysis of Synchronous Machines*, CRC Press,2017
5. K T Chau, *Electric Vehicle Machines and Drives – Design, Analysis and Application*, IEEE Wiley Press, 2015

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects and Report

CONTROL OF POWER CONVERTERS AND ELECTRICAL MACHINES

21AL713 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the design methodology of closed loop control of power converters through state space approach

LO2 To provide the concept of scalar and vector control techniques of various AC and DC motors

LO3 To study the concept of the synchronization methods and control of grid connected converters for V2G and G2V

LO4 To demonstrate the control AC and DC motors using various control techniques.

Course Outcomes (CO)

CO1 Ability to understand the concept of state space modelling of DC-DC converters.

CO2 Ability to apply methodologies to design analog and digital compensators for DC-DC converters.

CO3 Ability to analyze the open and closed loop control of various types of DC and AC motors using scalar and vector controllers.

CO4 Ability to investigate the control of grid connected converters for V2G and G2V

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	2	2
CO 2	-	-	2	-	2
CO 3	-	-	2	2	1
CO4	-	-	2	2	1

Skills acquired: Design of control algorithms for EV motor control applications.

Course Contents

Unit.1: (15 hours)

Concept of state space analysis - Power Converter Transfer Functions - State space representation and Transfer function model of a DC-DC converter - Control of Brushed DC Motors in EV applications - Open and closed loop control of chopper fed DC motors- Transfer function model of a separately excited DC motor - P- PI - PID controllers in DC motor control.

Unit.2: (15 hours)

Control of Induction Motors - Scalar and Vector control Technique (FOC & DTC) - Introduction to sensor less control - Control for Regeneration mode - Control of Permanent Magnet Synchronous Motors- Review of SPM - IPM concepts v/f control - Vector control- MTPA control.

Unit.3: (15 hours)

Control of Brushless DC motors - Drive operation with inverter - Torque speed curve- Machine dynamic model - Drive control - Extended speed operation - Control of Switched Reluctance motors in the context of vehicle power train control - Drive cycles performance and testing) - Closed loop control of Grid connected converters for V2G and G2V applications - Concept of Grid synchronization - Synchronous reference frame control and Hysteresis control.

References

1. Paul C.Krause, Oleg Wasynczuk, Scott D. Sudhoff and Steven Pekarek. *Analysis of electric machinery and drive systems*, 3rd Edition, IEEE press, 2013.
2. Krishnan, Ramu, *Electric Motor Drives: Modeling, Analysis, and Control*, Pearson Education India, 2015.
3. Ramu Krishnan, *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Press, 2017
4. Bimal K. Bose, *Modern Power Electronics and AC Drives*, John Wiley & Sons, 2002.
5. Frede Blaabjerg ed., *Control of Power Electronic Converters and Systems*, Vol. 1 & 2, Academic Press, 2018.
6. Haitham Abu-Rub, Atif Iqbal and Jaroslaw Guzinski eds., *High performance control of AC drives with MATLAB/Simulink models*, John Wiley & Sons, 2012.
7. KT Chau, *Electric Vehicle Machines and Drives – Design, Analysis and Application*, IEEE Wiley Press, 2015.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

SENSING FOR AUTONOMOUS VEHICLES

21AL721 **3-0-0-3**

Learning Objectives (LO)

LO1 To provide insight into the principles of 2-D and 3-D digital signal processing
LO2 To impart understanding the role of RF sensors in self-driving vehicular platform operations
LO3 To enable the realization in functionality of various other ADAS sensor systems

Course Outcomes (CO)

CO1 Ability to understand the principles of image and video signal processing
CO2 Ability to apply RADAR sensors and operations in self-driving vehicular platforms
CO3 Ability to analyze the functioning of various other sensor systems as part of ADAS

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	2
CO 2	-	-	3	3	3
CO 3	-	-	3	-	2

Skills Acquired: A ringside view on the wide spectrum of technologies that are enablers in autonomous vehicles.

Course Contents

Unit 1: (15 Hours)
Autonomous vehicles - Gradation of automated driving - Autonomous vehicle sensor categories - Visible light imaging sensors - Resolution - Steps in multi-dimensional digital signal processing - 2D & 3D signals, systems and transforms.

Unit 2: (15 Hours)
Automotive RADAR types - Radio frequency bands and standards - RADAR signal processing.

Unit 3: (15 Hours)
LiDAR Sensor - Reconstruction of point - cloud data - Ultrasonic sensors - GNSS and IMU sensors and systems - ADAS case studies.

References:

1. Hanky Sjafrie, *Introduction to Self-Driving Vehicle Technology*, First Edition, Chapman & Hall/CRC, 2019.
2. H. Winner et al. (Eds.), *Handbook of Driver Assistance Systems*, Springer Cham, 2016.
3. Luca Venturi and Krishtof Korda, *Hands-on Vision and Behavior for Self-Driving Cars*, Packt Publishing Limited, 2020.

4. K. S. Thyagarajan, *Introduction to Digital Signal Processing Using MATLAB with Application to Digital Communications*, First Edition, Springer International Publishing, 2019.
5. E. Byron, *Radar – Principles, Technology, Applications*, Third Indian Reprint, Pearson Education LPE, 2005.
6. J. Yoshida (Ed.), *Guide to Sensors in Automotive: Making Cars See and Think Ahead*, Aspencore Media, 2020.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

MULTI SENSOR DATA FUSION

21AL722 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the mathematical foundations of data fusion methods.
LO2 To impart an understanding of data fusion methods for automotive applications.
LO3 To provide insights into various intelligent fusion algorithms based on soft computing techniques.

Course Outcomes (CO)

CO1 Ability to understand the benefits and shortcomings of various data fusion algorithms.
CO2 Ability to apply appropriate data fusion techniques to problems in automotive applications.
CO3 Ability to analyse the intelligent fusion algorithms based on soft computing techniques.
CO4 Ability to create fusion models for automotive applications.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	-
CO 2	-	-	3	-	-
CO 3	-	-	3	3	3
CO4	-	-	3	3	-

Skills Acquired: Design of sensor-fusion based systems for automotive applications.

Course Contents

Unit 1: (15 Hours)
Introduction to data fusion process- Data fusion models- Configurations and architectures - Probabilistic Data Fusion-Maximum Likelihood- Bayesian- Maximum Entropy methods - Recursive Bayesian methods - Kalman filter theory- Kalman filter as a natural data-level fuser.

Unit 2: (15 Hours)
Data fusion by nonlinear Kalman filtering- Information filtering-H∞ filtering- Multiple hypothesis filtering- Data fusion with missing measurements- Possibility theory and Dempster-Shafer Method- ANN based decision fusion.

Unit 3: (15 Hours)
Decision theory based fusion- Bayesian decision theory- Decision making with multiple information sources- Decision making based on voting- Performance- Evaluation of data fusion systems- Monte Carlo methods - JDL process-Review of algorithms used for object refinement- Situation refinement- Threat refinement and process refinement.

References

1. Jitendra R Raol, *Data Fusion Mathematics: Theory and Practice*, CRC Press, 2016.
2. David L. Hall, Sonya A.H. McMullen, *Mathematical Techniques in Multisensor Data Fusion*, Second Edition, Artech House, Boston, 2004.
3. R. Brooks and S.S. Iyengar, *Multisensor Fusion: Fundamentals and Applications with Software*, Prentice Hall Inc., New Jersey, 1998.
4. James V. Candy, *Signal Processing: The Model Based Approach*, McGraw –Hill Book Company, 1987.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report

DEEP LEARNING AND APPLICATIONS

21AL723 **3-0-0-3**

Learning Objectives (LO)

LO1 To introduce the artificial neural networks and their architecture
LO3 To impart knowledge of artificial neural networks design for classification and sequence analysis.
LO4 To provide insight on design and deployment of deep learning models for machine learning problems.

Course Outcomes (CO)

CO1 Ability to understand the mathematics behind functioning of artificial neural networks.
CO2 Ability to analyze the given dataset for designing a neural network-based solution.
CO3 Ability to carry out design and implementation of deep learning models for signal/image processing applications.
CO4 Ability to design and deploy simple deep learning solutions to classification problems.

CO-PO Mapping

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	-	-	3	-	3
CO 2	-	-	3	2	3
CO 3	-	-	3	3	2
CO4	-	-	3	3	2

Skills acquired: Design and implementation of deep learning models for classification and sequence analysis.

Course Contents

Unit.1: (15 Hours)

Introduction to autonomous driving-Autonomous driving technologies-Autonomous driving algorithms - Perception in autonomous driving - Deep learning in autonomous driving perception -The Neuron - Feed-Forward Neural Networks - Linear neurons and their limitations – Activation functions - Training feed forward neural networks - Gradient descent - Delta rule and learning rates - Backpropagation algorithm - Stochastic and minibatch gradient descent - Preventing overfitting - Momentum-Based optimization-Learning rate adaptation.

Unit.2: (15 Hours)

Convolutional Neural Networks (CNN) architecture - Accelerating training with batch normalization - Visualizing learning in convolutional networks - Embedding and representation learning - Autoencoder architecture - Denoising - Sparsity in autoencoders.

Unit.3: (15 Hours)

Models for sequence analysis, Recurrent Neural Networks - Vanishing gradients - Long Short - Term Memory (LSTM) Units - Augmenting Recurrent networks with Attention - Deep Generative Networks - Generative Adversarial Networks - Deep Reinforcement Learning - Markov Decision Processes (MDP) - Explore versus Exploit - Policy versus Value learning - Q-Learning and Deep Q-Networks.

References

1. Nikhil Buduma, *Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms*, O'Reilly, 2017.
2. Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu and Jean-Luc Gaudiot. *Creating Autonomous Vehicle Systems*, Morgan & Claypool Publishers,2018.
3. Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press, 2016.
4. Aurélien Géron, *Hands-On Machine Learning with Scikit- Learn and TensorFlow*, O'Reilly, 2017.
5. Nikhil Ketkar, *Deep Learning with Python: A Hands-on Introduction*, Apress, 2017.

Evaluation Pattern:

Assessment	Internal	External
Periodical 1 (P1)	15	NA
Periodical 2 (P2)	15	NA
*Continuous Assessment (CA)	20	NA
End Semester	NA	50
Total	50	50

*CA – Can be Quizzes, Assignment, Projects, and Report