M.TECH PROGRAMME

AUTOMOTIVE ENGINEERING

CURRICULUM & SYLLABUS

DEPARTMENT OF MECHANICAL ENGINEERING

2024 Admission onwards

M. TECH – AUTOMOTIVE ENGINEERING

Department of Mechanical Engineering

About M.Tech - Automotive Engineering

The MTech program in Automotive Engineering is a multi-disciplinary program with the objective of inculcating advanced skills required to design and develop software defined vehicles. The department has the necessary infrastructure to guide budding engineers to become experts in the design and development of hybrid and electric vehicles, and impact the necessary skill set for designing Advanced Driver Assistance Systems (ADAS).

The program is supported by automotive industry knowledge partners and their collaboration, graduate students will have an opportunity to understand the state-of-the-art technologies in EV, Automotive Electronics, and ADAS by solving real-world automotive problems.

Besides mandatory core courses, several electives are offered to the students to suit their acumen in the emerging areas and are designed by professionals from the industry. The students are periodically assessed by experts, and they are also motivated to take up internships in the Industry. Since India is being recognized as a hub for the global players, this course is committed to produce automotive engineers with creative capabilities and caliber to solve challenging problems and is in tune with the objectives envisioned by the University.

Vision of the Institute

To be a global leader in the delivery of engineering education, transforming individuals to become creative, innovative, and socially responsible contributors in their professions.

Mission of the Institute

- To provide best-in-class infrastructure and resources to achieve excellence in technical education
- To promote knowledge development in thematic research areas that have a positive impact on society, both nationally and globally
- To design and maintain the highest quality education through active engagement with all stakeholders – students, faculty, industry, alumni and reputed academic institutions
- To contribute to the quality enhancement of the local and global education ecosystem
- To promote a culture of collaboration that allows creativity, innovation, and entrepreneurship to flourish, and
- To practice and promote high standards of professional ethics, transparency, and accountability.

Vision of the Department

To transform our students into outstanding mechanical engineers with strong domain knowledge and skills, society-centric research intent, and exemplary ethical values, making them the most desired professionals by research institutions, industry and society.

Mission of the Department

- To develop in each student, a profound understanding of fundamentals, motivation for continuous learning, and practical problem-solving skills for building a successful career.
- To create and share technical knowledge and collaborate with industry and institutions for the betterment of society.
- To imbibe ethical values, leadership qualities and entrepreneurial skills in students.
- To sustain a conducive environment to involve students and faculty in research and development.

Program Educational Objectives (PEOs)

PEO1: To provide techno commercial solutions to practical problems in automotive sector.
PEO2: To use computational, analytical, experimental tools and techniques to solve complex problems.
PEO3: To solve multidisciplinary problems by working in cross-functional teams with effective communication and technical skills.
PEO4: To upgrade technical knowledge, intellectual, leadership and entrepreneurial skills to compete in an evolving environment.

Mission Statement - PEO Mapping

Mapping	M1	M2	M3	M4
PEO1	3	2	1	2
PEO2	2	3	1	3
PEO3	1	2	1	2
PEO4	1	2	3	2

Program Outcomes (POs)

On completion of the M.Tech (Automotive engineering) program, the graduate will be able to

PO1: Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO2: Independently carry out research/investigation and development work to solve practical problems.

PO3: Write and present a substantial technical report/document.

PO4: Design power train, drives and control systems for electric and hybrid vehicle by understanding their fundamental operating principles and their characteristics.

PO5: Integrate sensors and develop software solutions for advanced driver assistance systems towards the development of software defined vehicles.

CURRICULUM

First Semester

Bridge Course: A comprehensive bridge course has been designed to equip students with essential mathematical foundations and programming proficiency crucial for their academic journey and future endeavours in automotive engineering. This intensive course aims to bridge the gap between prior knowledge and the rigorous demands of the program, ensuring all students possess a solid understanding of fundamental concepts in mathematics and programming languages.

The mathematics segment of the bridge course encompasses a diverse array of topics essential for the comprehension and analysis of advanced engineering principles. Students will be familiarized with Calculus, Linear Algebra, Transforms, Statistics, ODE and PDE. In parallel with mathematical concepts, students will be introduced to a versatile programming language, such as Python/MATLAB, to facilitate computational analysis and problem-solving in engineering contexts. Through hands-on exercises and projects, students will gain proficiency in Basic Syntax and Data Structures, Numerical Computing, Plotting and Visualization, Algorithm Implementation and Integration with engineering applications.

First Semester

Course Code	Type	Course	L T P	Cr
24AT601	FC	Automotive Systems	3 0 0	3
24AT602	FC	Electric Drives and Controls	3 0 0	3
24AT603	FC	Automotive Electronics	3 0 0	3
24AT604	FC	Model Based System Design	2 0 3	3
24AT605	SC	Data Science and Analytics	2 0 3	3
24AT681	FC	Automotive Laboratory	0 0 3	1
	E	Elective I	3 0 0	3
22AVP103	HU	Mastery Over Mind	1 0 2	2
22ADM501	HU	Glimpses of Indian Culture	2 0 1	P/F
23HU601	HU	Career Competency I*	0 0 3	P/F
		Credits		**21**

*** Non-credit course**

Second Semester

Course Code	Type	Course	L T P	Cr
24AT611	SC	Introduction to Electric Vehicles	3 0 0	3
24AT612	SC	Embedded System	2 0 3	3
24AT613	SC	Introduction to Software Defined Vehicles	3 0 0	3
24AT614	SC	Advanced Driver Assistance System	2 0 3	3
24AT615	SC	Vehicle Dynamics and Simulation	2 0 3	3
	E	Elective II	3 0 0	3
	E	Elective III	3 0 0	3
23HU611	E	Career Competency II	0 0 3	1
24RM601		Research Methodology		P/F
		Credits		**22**

Third Semester

Course Code	Type	Course	L T P	Cr
24AT798	P	Dissertation-I		10
			Credits	**10**

Fourth Semester

Course Code	Type	Course	L T P	Cr
24AT799	P	Dissertation-II		16
			Credits	**16**
			Total Credits	**69**

L- Lecture; T-Tutorial; P-Practical; FC- Foundation Core; SC- Subject Core; HU-Humanities; ADM-Amrita Darshanam; E-Electives; P- Dissertation; P/F- Pass/Fail

List of Courses

Foundation Core

24AT601	FC	Automotive Systems	3 0 0	3
24AT602	FC	Electric Drives and Controls	3 0 0	3
24AT603	FC	Automotive Electronics	3 0 0	3
24AT604	FC	Model Based System Design	2 0 3	3
24AT681	FC	Automotive Laboratory	0 0 3	1

Subject Core

24AT605	SC	Data Science and Analytics	2 0 3	3
24AT611	SC	Introduction to Electric Vehicles	3 0 0	3
24AT612	SC	Embedded System	2 0 3	3
24AT613	SC	Introduction to Software Defined Vehicles	3 0 0	3
24AT614	SC	Advanced Driver Assistance System	2 0 3	3
24AT615	SC	Vehicle Dynamics and Simulation	2 0 3	3

Elective Streams

(Students can choose their electives from any one of the below streams based on their career goals or can have a mixed choice of electives across the streams)

Software Defined Vehicles

Course Code	Course	L	T	P	Cr
24AT731	Control Systems for Autonomous Vehicles	3	0	0	3
24AT732	Real-Time Operating Systems	2	0	3	3
24AT733	Automotive User Experience (UX) Design	3	0	0	3
24AT734	Vehicular Communication	3	0	0	3
24AT735	Cybersecurity for Automotive Systems	3	0	0	3
24AT736	Multi Sensor Data Fusion	3	0	0	3

Electric and Hybrid Vehicles

Course Code	Course	L	T	P	Cr
24AT741	Design of Battery Pack and Thermal Modelling	2	0	3	3
24AT742	Battery Management System	2	0	3	3
24AT743	Charging Infrastructure	3	0	0	3
24AT744	Energy Management in Electric and Hybrid Vehicles	3	0	0	3
24AT745	Fuel Cell Technology	3	0	0	3
24AT746	Hybrid Electric Vehicles	3	0	0	3

General Electives

Course Code	Course	L	T	P	Cr
24AT751	Noise, Vibration and Harshness	2	0	3	3
24AT752	Automotive Safety Systems	3	0	0	3
24AT753	Vehicle Body Engineering	3	0	0	3
24AT754	Automotive Testing and Validation	3	0	0	3
24AT755	Automotive Emission and Control	3	0	0	3
24AT756	Computational Fluid Dynamics	2	0	3	3
24AT757	Finite Element Methods and Analysis	2	0	3	3

Project Work

Course Code	Course	L	T	P	Cr
24AT798	Dissertation-I				10
24AT799	Dissertation-II				16

EVALUATION PATTERN

<table>
<tr><td>Course Type</td><td>Int : Ext</td><td colspan="7">Evaluation Scheme</td><td colspan="2">Total (100)</td></tr>
<tr><td colspan="11">Theory, Lab integrated and Pass/Fail (P/F) Courses</td></tr>
<tr><td rowspan="2">L T P</td><td rowspan="6">60 : 40</td><td>CA1</td><td>CA2</td><td>MT</td><td>CA3</td><td>CA4</td><td>ES</td><td colspan="2">Internal (60)</td><td>External (40)</td></tr>
<tr><td>Q1 /AI</td><td>Q2/ A2</td><td>Exam</td><td>Q3/ A3</td><td>Q4/ A4</td><td>Exam/ Project*</td><td colspan="2">CA1+CA2+ MT+CA3+CA4</td><td>ES</td></tr>
<tr><td>X 0 0</td><td rowspan="4">7.5</td><td rowspan="4">7.5</td><td rowspan="4">30</td><td rowspan="4">7.5</td><td rowspan="4">7.5</td><td rowspan="4">40</td><td colspan="2" rowspan="4">60</td><td rowspan="4">40</td></tr>
<tr><td>X Y 0</td></tr>
<tr><td>X 0 Z</td></tr>
<tr><td>P/F</td></tr>
<tr><td colspan="11">Lab Based Courses</td></tr>
<tr><td rowspan="3">0 0 Z</td><td rowspan="3">60 : 40</td><td colspan="2">6 weeks Task or Exp. (CA1)</td><td rowspan="3">MT</td><td colspan="2">6 weeks Task or Exp. (CA2)</td><td>ES</td><td colspan="3">Total (100)</td></tr>
<tr><td colspan="2">No. of Task based on the course</td><td colspan="2">No. of Task based on the course</td><td>Exam/ Project*</td><td colspan="2">Internal (CA1+MT+ CA2)</td><td>External (ES)</td></tr>
<tr><td>1 0 Z</td><td colspan="2">20</td><td>20</td><td colspan="2">20</td><td>40</td><td colspan="2">60</td><td>40</td></tr>
<tr><td colspan="11">Dissertation / Internship</td></tr>
<tr><td rowspan="5">DISSERTATION / INTERNSHIP</td><td rowspan="5">60 : 40</td><td colspan="5">CA (60)</td><td>ES (40)</td><td colspan="3">Total (100)</td></tr>
<tr><td colspan="9">Dissertation Phase 1 & Phase 2</td></tr>
<tr><td colspan="5">Based on Review by panel of experts</td><td>External review</td><td colspan="3">CA+ES</td></tr>
<tr><td colspan="9">Internship</td></tr>
<tr><td colspan="5">External report (Industry / Research Organization)</td><td>Presentation & Internship Report</td><td colspan="3">CA+ES</td></tr>
</table>

Nomenclature

L	: Lecture	T	: Tutorial
P	: Practical	Int	: Internal
Ext	: External	CA	: Continuous Assessment
MT	: Mid-Term	ES	: End Semester Examination
Exp.	: Experimental work	X	: No. of Lecture hours per week
Y	: No. of Tutorial hours per week (1)	Z	: No. of practical hours per week
Q	: Quiz	A	: Assignment
DIS	: Dissertation		

* : Project component (in-lieu of end semester examination) only for the selected courses as decided by the department level committee

SEMESTER 1

24AT601 AUTOMOTIVE SYSTEMS 3-0-0-3

Course Objectives

1. To familiarize vehicle architecture, including chassis and suspension systems, and internal combustion engine operation.
2. To demonstrate steering systems, wheel alignment, and suspension tuning for optimal performance.
3. To explore transmission types and braking principles, including hydraulic systems and advanced technologies.
4. To provide an overview of automotive electrical systems, drivetrain layouts, and safety systems.

Course Outcomes

CO	CO Description
CO1	Identify and explain vehicle components and configurations.
CO2	Analyze and adjust steering and suspension for improved vehicle handling.
CO3	Understand transmission types and assess braking systems.
CO4	Acquire knowledge of electrical systems and safety features in automotive contexts.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	2	1
CO2	3	1	1	2	1
CO3	3	1	1	3	1
CO4	3	1	1	1	1

Skills acquired

Develop comprehensive skills in vehicle diagnostics, maintenance, and safety protocols, covering steering, suspension, transmission, braking, electrical systems, and industry standards compliance

Unit 1 15 hours

Introduction- Vehicle subsystems: Introduction to vehicle architecture - Chassis types and construction- Suspension types and components- Internal combustion engine operation-Engine types and configurations-air standard cycles - engine components and their functions-Engine cooling and lubrication systems. Steering systems and their operation-Wheel alignment - Steering Linkage - Power Assisted Steering Operation – Alignment. Suspension System Components and Operation - Front and rear suspension.

Unit 2 15 hours

Transmission types and operation: Clutch-single plate, multi plate -Dual clutch- Gearbox- Sliding mesh, constant mesh, synchromesh gear boxes and differential components - Automatic and Hybrid Drives - Continuously Variable Transmissions. Principles of braking-Brake types and components - Drum and Disc Brakes- Hydraulic Systems - -Anti-lock braking systems (ABS) and electronic brake-force distribution (EBD).

Unit 3 15 hours

Basics of automotive electrical system: Battery operation, types and maintenance-Charging and starting systems- Electrical circuits and wiring in vehicles, -Lighting and-signalling systems. Drivetrain layout and power distribution-Hybrid and electric powertrain technologies. Automotive safety systems-Active and Passive safety-Overview of testing and homologation standards.

Text Books / References

1. Tom Denton and Hayley Pells, “Automobile Mechanical and Electrical Systems”, Third Ed., Routledge, 2023.
2. Heywood J B, “Internal Combustion Engine Fundamentals”, McGraw-Hill, 2017.
3. Heinz Heisler, “Vehicle and Engine Technology”, Butterworth-Heinemann, 2010.
4. S.K. Gupta, “Automobile Engineering”, S.Chand Publishing, 2nd edition, 2020.
5. Colin R. Ferguson, Allan T. Kirkpatrick, “Internal Combustion Engines: Applied Thermo-sciences”, 3rd Edition, John Wiley and Sons, 2015.
6. Rudolf Limpert, “Brake design and Safety”, SAE Publications, 2015.

24AT602 ELECTRIC DRIVES AND CONTROLS 3-0-0-3

Course Objectives

1. To inculcate conceptual framework and classification of electric drives, emphasizing motor selection and dynamics
2. To demonstrate the basic characteristics and types of DC motors, operational modes, and various control schemes
3. To elaborate on the intricacies of induction motor drives, including stator voltage control, rotor voltage control, slip power recovery and closed loop control
4. To enable practical skills on testing motor characteristics.

Course Outcomes

CO	CO Description
CO1	Develop a conceptual framework and classification of electric drives, emphasizing motor selection and dynamics
CO2	Proficiency in the operation and control of DC motor drives,
CO3	Demonstrate expertise in rectifier-fed drives, chopper drives, and effective closed-loop control strategies.
CO4	Design induction motor drives, including advanced control methods like V/f control and closed-loop schemes.
CO5	Apply practical skills in hardware implementation for DC and induction motor speed control in both closed-loop and open-loop configurations.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	3	2
CO2	3	2	1	3	2
CO3	3	2	1	3	2
CO4	3	2	1	3	2

Skills acquired

Expertise in motor selection, dynamic analysis, and stability considerations for electric drives, and advanced control proficiency in DC and AC motor drives, with practical skills in implementing closed-loop control strategies

Unit 1 12 hours

Introduction: Concepts, and classification of Electric drives. Selection of motors. Dynamics of Electric drives: Types of loads, Multi quadrant operations, motor dynamics steady state stability and transient stability. Rating and Heating of motors: Heating effects, heating and cooling curves, classes of duty, load equalization, environmental factors.

Unit 2 16 hours

DC motor drives: Basic characteristics, Operating modes, Single phase and three phase-controlled rectifier fed DC drives, Dual converters drives, Chopper drives, Rheostatic and regenerative braking, effects of changes in supply voltage and load torque, closed loop control schemes. Induction motor drives, stator voltage control, stator impedance control, rotor voltage control- Slip power recovery, Concepts of Static Kramer drives and Static Scherbius drive, V/f control, Current control method. Need for harmonic filter, closed loop control. Introduction to vector control scheme.

Unit 3 **17 hours**

Synchronous motors: Speed torque characteristics and torque angle characteristics. Fixed and variable frequency operation modes, Self-control modes. Special machines: Brushless DC motor, Switched Reluctance Motor, Stepper Motor, introduction to the relevant converter circuits. Hardware- DC Speed control- Converter fed DC motor – Induction motor drive- Speed Control-Closed loop and open loop. Virtual lab/ Simulation - Phase controlled DC motor drives, Chopper controlled DC motor drives-modelling of DC motor-modelling of induction motor- Closed loop control of DC and AC Drives. Introduction to axial flux motors.

Text Books / References

1. Pillay. S.K, A First Course on Electric Drives, Wilely Eastern Limited, Bombay, 2022
2. Ramu Krishnan, Permanent Magnet Synchronous and Brushless DC Motor Drives, CRC Press, 2019
3. B.K Bose, 'Power Electronics and AC Drives', Prentice Hall, New Jersy, 2020.
4. Gopal K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2001
5. Emadi, Ali, Advanced Electric Drive Vehicles, CRC Press 2014
6. R.Krishnan, 'Electric Motor Drives, Modeling, Analysis and Control', Prentice Hall, NJ, 2001.
7. K T Chau, Electric Vehicle Machines and Drives – Design, Analysis and Application, IEEE Wiley Press, 2015.

24AT603 **AUTOMOTIVE ELECTRONICS** **3-0-0-3**

Course Objectives

1. To familiarize various sensors and actuators used in a vehicle
2. To introduce controller design control for drive by wire system
3. To familiarize usage of controllers and sensors for implementation of simple automotive electronic hardware
4. To familiarize the working of starting, charging system and vehicle networks

Course Outcomes

CO	CO Description
CO01	Select suitable sensors and actuators for automotive applications.
CO02	Design control systems for drive by wire systems
CO03	Make use of controllers and sensors for implementation of simple automotive electronic hardware
CO04	Understand the working of starting, charging system and vehicle networks.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	2	2
CO2	3	2	1	2	3
CO3	3	2	1	2	3
CO4	3	2	1	2	2

Skills acquired

Make use of controllers and sensors for implementation of simple automotive electronic hardware

Unit 1 **16 hours**

Introduction to Electronic systems in Automotives: Introduction, Sensors and Actuators for body electronics, power train and chassis systems. Body electronics domain- Automotive alarms, Lighting, Central locking and electric windows, Climatic Control, Driver information, parking, etc. Power train and chassis control domain – Engine management , Transmission control, ABS, ESP, Traction Control, Active Suspension, passive safety, Adaptive Cruise Control, etc.

Unit 2 **12 hours**

Signal Processing and Converters: introduction - Discrete-Time Signals and Systems- Time-Domain Analysis- Digital Filters- Analog-to-Digital Converters (ADCs) and Digital-to-Analog Converters (DACs)- Sampling and Reconstruction. Network protocols- LIN, CAN, FlexRay, MOST etc.

Unit 3 **17 hours**

Automotive Radar: Frequency Band Allocation and Standards – Elements of Automotive Radar – Antenna Systems and Requirements – Antenna Mounting – Radio Frequency Front End – Radar Signal Processors Requirements – Waveform Generation – Range Estimation – LIDAR: LIDAR based sensing-LIDAR Applications in Automotive systems. Vehicle network and communication buses – Digital engine control systems, Introduction to automotive controllers, On-Board Diagnostics (OBD). Introduction to BMS.

Text Books / References

1. Bosch, “Automotive Electrics and Automotive Electronics. System and components ,Networking and Hybrid drive”, Sixth edition, Springer, 2021
2. Najamuz Zaman, “Automotive Electronics Design Fundamental’’ first edition, Springer 2015.
3. William B. Ribbens, “Understanding Automotive Electronics” Eighth Edition, Butterworth - Heinemann, 2017
4. Alan V. Oppenheim, Alan S. Willsky, and S. Hamid Nawab, Signals & Systems, 2nd Edition, 2018
5. Emmanuel C. Ifeachor and Barrie W. Jervis , “Digital Signal Processing: A Computer-Based Approach” , 4th Edition, 2018

24AT604 **MODEL BASED SYSTEM DESIGN** **2-0-3-3**

Course Objectives

1. To introduce the fundamental concepts and principles behind the modelling of physical systems,
2. To provide insight on various reduced order modelling techniques and their applications, including data-driven models and dynamic ROM using Deep Learning networks
3. To familiarize the governing equations of vehicle dynamics and apply reduced order modelling techniques to simplify and improve models, leveraging experimental data
4. To familiarize in modelling of motor , battery pack models, HIL, SIL and MIL

Course Outcomes

CO	CO Description
CO01	Understand the principles of modelling physical systems, including linear and non-linear systems.
CO02	Apply reduced order modelling techniques to simplify complex system dynamics, including data-driven approaches and Deep Learning networks.
CO03	Analyse and model vehicle dynamics, including longitudinal, lateral, and vertical dynamics
CO04	Develop models for motor, transmission, battery pack, driver, and brake systems, incorporating governing equations, data-driven approaches.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	2	2
CO2	3	3	1	2	2
CO3	3	3	1	3	2
CO4	3	3	1	2	3

Skills acquired

Model diverse physical systems, employ reduced order modelling techniques, utilize Simulink blocks, and optimize models for simulation.

Unit 1 **8 hours**

Physical System Modelling: Introduction – Modelling of physical system – Linear System, non – linear system, System governed by PDE and ODE. Reduced Order Modelling – Types of ROM – Data driven models and dynamic ROM using Deep Learning networks. Introduction to Simulink blocks set.

Unit 2 **12 hours**

Vehicle Dynamics Modelling – Introduction to governing equations of longitudinal, lateral and vertical dynamics of vehicle. Reduced order modelling of vehicle dynamics equations and improving models using Coast Down Test results. Motor and Transmission Modelling – Introduction to modelling of simple DC motor governing equations. Data driven modelling of generic motor. Maps/Lookup tables relating speed torque, power delivered, current drawn and efficiency of motors for model improvements. Adopting transmission and final drive gear ratios and efficiencies.

Unit 3 **10 hours**

Battery Pack, Drive and Brake Modelling: – Introduction to battery parameters – Open circuit voltage, internal resistance and n – RC models of battery packs. Introduction to standard driving cycles and PID controller. Simple driver model using driving cycle and PID controller. Simplified brake modelling – Usage of opposing torque. Introduction to systems engineering- model based systems engineering and its application to automobile systems.

List of experiment with Matlab /Python **45 hours**

1. Developing a Reduced-Order Model of a Physical System using Deep Learning
2. Model Predictive Control of a Vehicle using Simulink
3. Characterizing and Modelling a DC Motor using Data-Driven Techniques
4. Battery Modelling and Simulation for Electric Vehicle Performance Analysis
5. PID-Based Driver Model Design and Implementation in MATLAB/Simulink
6. Optimizing Vehicle Dynamics Model Response through Rate Limiters and Saturation
7. From MATLAB Model to Reality: Exploring Model-in-the-Loop (MIL) and Hardware-in-the-Loop (HIL) Simulation
8. Implementing a Simplified Brake Model using Opposing Torque in Simulink
9. Investigating the Impact of Transmission Characteristics on Vehicle Performance

Text Books / References

1. "System Dynamics Modeling with MATLAB and Python by Edward O. Pytlak: Chapman and Hall/CRC, 2023.
2. Mehrdad Ehsani, Yimi Gao, Sebastian Longo, Kambiz Ebrahimi, “Modern Electric, Hybrid Electric and Fuel Cell vehicles: Fundamentals, Theory and Design”, CRC Press, Third edition, 2022.
3. https://matlabacademy.mathworks.com/details/simulink-onramp/simulink
4. https://matlabacademy.mathworks.com/details/simulink-fundamentals/slbe
5. INCOSE ed., INCOSE systems engineering handbook. John Wiley & Sons, 2023.
6. Haberfellner, Reinhard, Peter Nagel, Mario Becker, Alfred Büchel, and Heinrich von Massow. Systems engineering. Cham: Springer International Publishing, 2019.

24AT605 DATA SCIENCE AND ANALYTICS 2-0-3-3

Course Objectives

1. Inculcate the knowledge about various deep learning methods and its automotive applications
2. Impart the concepts to formulate a deep learning model for autonomous vehicle applications.
3. Enable to use the computational tools for solving real time problems in autonomous Vehicles.

Course Outcomes

CO	CO Description
CO1	Develop a machine learning model with the help of classification and regressions methods.
CO2	Acquire comprehensive understanding of neural network architectures, optimization algorithms and activation functions involved in neural networks
CO3	Formulate a deep learning model using various deep learning methods for autonomous vehicle applications.
CO4	Apply deep learning techniques to solve problems pertinent to autonomous vehicles using computational tools.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	1	2
CO2	3	2	1	2	2
CO3	3	2	1	2	3
CO4	3	2	2	3	3

Skills acquired

Develop expertise in autonomous driving technologies, mastering perception algorithms, deep learning, and reinforcement learning for effective implementation in autonomous systems.

Unit 1 10 hours

Machine learning - Basic motivation, examples of machine learning applications, supervised, unsupervised and reinforcement learning. Support Vector classification and K-Means clustering. Fundamentals of artificial neural networks (ANNs), Building blocks of neural networks: neurons, layers, and activation functions, Training neural networks using gradient descent and back propagation. ANN based regression model.

Unit 2 10 hours

Deep learning - Introduction, Convolutional Neural Networks (CNNs) - Understanding CNN architecture, Convolutional layers, pooling layers, and fully connected layers, Training CNNs for image classification tasks. Recurrent Neural Networks (RNNs) -Introduction to RNNs and their applications in sequential data analysis, Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) architectures, Training RNNs for time series prediction.

Unit 3 10 hours

Advanced Deep Learning Techniques - Introduction to advanced deep learning architectures: Generative Adversarial Network,(GANs), autoencoders, and reinforcement learning, Applications of GANs in generating synthetic data for automotive engineering tasks, Implementing autoencoders for anomaly detection and dimensionality reduction.

Lab Content: (MATLAB/Python/other open-source software) 45 hours

1. Image Classification: Training a CNN to classify road signs and traffic signals.
2. Object Detection: Implementing a YOLO (You Only Look Once) model for detecting vehicles and pedestrians.
3. Lane Detection: Developing a deep learning model to detect and track lane markings.
4. Semantic Segmentation: Using a CNN to segment road scenes into different classes (road, vehicles, pedestrians).
5. Trajectory Prediction: Implementing an LSTM network to predict the future trajectories of other vehicles.

6. Path Planning: Developing a reinforcement learning algorithm to navigate an autonomous vehicle through a simulated environment.
7. Localization: Implementing a particle filter-based localization algorithm to estimate the vehicle's position.
8. Sensor Fusion: Integrating data from multiple sensors (camera, LiDAR, radar) to detect and track objects.
9. Simulation: Building a simulation environment for testing autonomous vehicle algorithms and training models.
10. Real-world Testing: Deploying trained models on an autonomous vehicle platform for real-world testing and validation.

Text Books / References

1. Nikhil Buduma, “Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms”, O’Reilly, 2020.
2. Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu and Jean-Luc Gaudiot. “Creating Autonomous Vehicle Systems”, Morgan & Claypool Publishers, 2021.
3. Ian Goodfellow, Yoshua Bengio and Aaron Courville, “Deep Learning”, MIT Press, 2016.
4. Aurélien Géron, “Hands-On Machine Learning with Scikit- Learn and Tensor Flow”, O’Reilly, 2019.
5. Nikhil Ketkar, “Deep Learning with Python: A Hands-on Introduction”, Apress, 2017.

24AT681 AUTOMOTIVE LABORATORY 0-0-3-1

Course Objectives

1. To demonstrate the basic characteristics and types of DC motors, operational modes, and various control schemes
2. To enable practical skills on testing motor characteristics.
3. To familiarize usage of controllers and sensors for implementation of simple automotive electronic hardware
4. To familiarize the working of vehicle networks and communication

Course Outcomes

CO	CO Description
CO1	Proficiency in the operation and control of DC motor drives,
CO2	Apply practical skills in hardware implementation for DC and induction motor speed control in both closed-loop and open-loop configurations.
CO3	Make use of controllers and sensors for implementation of simple automotive electronic hardware
CO4	Understand the working of vehicle networks and communication concepts

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	3	2
CO2	2	2	1	3	2
CO3	3	2	1	2	3
CO4	2	2	1	2	3

Skills acquired

Acquire practical skills in motor characterization, control techniques, microcontroller programming, signal processing, and understanding communication protocols for automotive electronics.

Lab Content: (Electrical Drives and Controls)

1. Characterization of DC Motor
   a. To observe open-loop speed control of a DC motor
   b. To calculate the motor back-emf constant
   c. To calculate the electrical parameters (Ra and La) of the motor using the blocked rotor test
   d. Verify the voltage vs speed characteristics of the DC motor
   e. Plot the torque-speed characteristics of the DC motor with load
2. Speed control of a DC motor
   a. Control the speed of a DC motor using an open-loop voltage.
   b. Use PI control on the armature current and speed individually.
3. Obtain waveforms of 3-phase full controlled bridge converter with R, RL and loads.
4. Characteristics of a Permanent Magnet AC motor
   a. Observe the back emf of the motor and calculate its back emf constant
   b. Run the motor with current control by correct placement of the current space vector
   c. Run the motor with speed control
5. Torque-speed characteristics and speed control of a three-phase induction motor

(Automotive Electronics)

1. MK40DX256 board GPIO introduction
2. Button Debouncing with MK40DX256 both software and hardware
3. 7-Segment Display Control
4. Signal Processing - Real-Time Frequency Analysis, Perform Fast Fourier Transform (FFT) on the acquired sensor data using specialized libraries.
5. Signal Processing with External ADC/DAC- Implement advanced signal processing algorithms like demodulation, modulation, or filter design.
6. Timer-Based Signal Generation and PWM to control motor.
7. CAN communication with MK40DX256
8. CAN X by wire with MK40DX256

SEMESTER 2

24AT611 INTRODUCTION TO ELECTRIC VEHICLES 3–0–0–3

Course Objectives

1. To demonstrate the fundamentals of electric vehicle propulsion, such as power flow regulation and drive-train topologies.
2. To predict the efficiency of the drive system by analyzing the electric propulsion units and their components.
3. To provide an overview on electric vehicles, energy storage needs and battery technologies.
4. To familiarize in design principles to size drive systems effectively and implement control systems for efficient vehicle operation.

Course Outcomes

CO	CO Description
CO1	Comprehend the core principles of electric vehicle design, including hybrid traction concepts and drive-train topologies.
CO2	Analyze electric drive-train architectures to optimize efficiency and fuel consumption, considering power flow control and torque coupling.
CO3	Select appropriate electric propulsion units for vehicles, evaluating motor types and system efficiency.
CO4	Demonstrate proficiency in designing electric vehicles, including energy storage, battery selection, drive system sizing, and implementing control systems for efficient operation.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	3	3
CO2	2	1	1	3	3
CO3	3	1	1	3	3
CO4	3	1	1	3	3

Skills acquired

Electric and hybrid drive-train systems, electric propulsion units, energy storage technologies, drive system sizing, and energy management strategies for hybrid and electric vehicles.

Unit 1 15 hours

Electrical vehicle system and configurations: Various electric drive-train topologies – power flow control in electric drive-train topologies – fuel efficiency analysis – Electric Propulsion unit – Introduction to electric components –Transmission types for EV – Power Flow Control in Electric Drivetrain – Positioning of Motors – Vehicle Performance – Tractive Effort – Drive cycles. Motor Drives: Types of Motors in EV – Characteristics features of EV motors – Torque Speed Characteristics – Drive system Efficiency – EV Motor Cooling.

Unit 2 13 hours

EV Power Electronics: Electric Drive Components – Introduction to Power electronic components – DC Drives – DC Regulation and Voltage Conversion – Motor Drives Performance parameters of DC-DC conversion – Step-up and step-down converters with RL load – Switching mode regulators – Comparison of converters – Inverter's introduction Principle of operation – Three phase inverters – Voltage control of three phase inverter– Regenerative Braking Systems.

Unit 3 17 hours

EV Charging and Energy Storage: Battery charging modes – Types of EV supply equipment (EVSE) – components of EV battery chargers – charging infrastructure challenges classification based on charging levels (region-wise) – modes – plug types – standards related to: connectors, communication – supply equipment – EMI/EMC –AC-DC converters types and working principles – DC-DC converters types and working principles. Battery range – Battery types – Battery parameters – Battery Terminology – Units of Battery Energy Storage – Performance criterion for EV batteries – Battery Pack – Traction Battery Pack design – Battery Temperature,

Heating and Cooling Needs – Thermal Management of Batteries –Vehicle-to-Grid (V2G) Technology – Alternative energy storage technologies.

Project

Students must complete any one of the projects mentioned below,

1. Design a specific subsystem for an electric or hybrid vehicle:
   This could be a battery pack, electric motor, powertrain component, or even a charging system.
2. Analyze the energy consumption of an electric or hybrid vehicle:
   This project could involve using simulation software or real-world data to estimate the energy consumption of a specific vehicle under different driving conditions.
3. Perform a feasibility study for deploying electric or hybrid vehicle infrastructure:
   This project could focus on a specific region or community and involve researching factors like charging infrastructure needs, potential user demographics, and economic considerations.

Text Books / References

1. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, Second Edition, 2021.
2. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz M. Ebrahimi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", CRC Press, Third Edition, 2018
3. James Larminie, John Lowry, "Electric Vehicle Technology", Wiley, Second edition, 2012.
4. Tom Denton, "Electric and Hybrid Vehicles", Routledge, Third Edition, 2024
5. Patel, N., Bhoi, A. K., Padmanaban, S., & Holm-Nielsen, J. B. "Electric vehicles: modern technologies and trends". Springer, 2021.

24AT612 **EMBEDDED SYSTEM** **2-0-3-3**

Course Objectives

1. To acquire knowledge on fundamental concepts of embedded systems, distinguishing them from general-purpose computing systems.
2. To familiarize various architectures of embedded systems, including ARM Cortex M, and comprehend their features and programming models.
3. To imbibe knowledge about embedded operating systems and their role in the development of embedded products, including the embedded system Development Life Cycle (EDLC).
4. To develop embedded software using the C programming language, focusing on automotive application.

Course Outcomes

CO	CO Description
CO1	Identify the unique characteristics of embedded systems.
CO2	Describe various features of ARM Cortex Microcontroller.
CO3	Analyse the significance in the embedded product development life cycle.
CO4	Develop automotive applications using embedded systems.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	2		1	1	3
CO2	2	1	1	1	3
CO3	3	1	1	1	3
CO4	3	2	1	3	3

Skills acquired

Embedded systems fundamentals, microcontroller, automotive networks and EDLC.

Unit 1 **10 hours**

Embedded vs. General Computing Systems: Overview of Embedded Architecture, Components of Embedded Systems. ARM Cortex-M Features, Block Diagram and Programming Model, GPIO, ADC and PWM Interfacing, Embedded Software Development using C. Introduction to real time operating system (RTOS)-Types, characteristics, functions.

Unit 2 **10 hours**

CAN & Wireless networks: RS232, Controller Area Networks (CAN) - physical layer and bit coding-frame types and format-Bit stuffing and synchronization - error management, Wireless Networking Technologies.

Unit 3 **10 hours**

EDLC: Electronic control units, Diagnostics, Embedded Operating Systems, Embedded System product Development Life cycle (EDLC).. Case Study: Implementation of Embedded Systems for Lane Departure Warning Systems.

Lab components 45 hours

1. GPIO Interfacing using Bosch Freescale kit.
2. Interfacing of Temperature sensor using Bosch Freescale kit.
3. ADC using Bosch Freescale kit.
4. PWM generation using Bosch Freescale kit.
5. Interfacing of relay using Bosch Freescale kit.
6. Interfacing of DC motor using Bosch Freescale kit.
7. Implementation of RS232 communication protocol using Bosch Freescale kit.
8. Implementation of CAN communication protocol using Bosch Freescale kit.

Text Books / References

1. Lasiuk, Z., Verma, P., & Andrews, J. “The Insider’s Guide to Arm Cortex-M Development: Leverage embedded software development tools and examples to become an efficient Cortex-M developer”, Packt Publishing; 1st edition , 2022.
2. Wolf, Computers as Components: Principles of Embedded Computing System Design, Elsevier, 2019.
3. Joseph Yiu ,“The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors”, Newnes; 3rd .edition, 2013
4. David J. Katz and Rick Gentile, “Embedded Media Processing”, Elsevier India Private Limited, New Delhi, First Edition, 2006
5. Shibu KV, “Introduction to Embedded System”, Tata McGraw-Hill, First Edition, 2011
6. Rajkamal, “Embedded Systems Architecture, Programming and Design”, Tata McGraw-Hill, Second Edition, 2003

24AT613 INTRODUCTION TO SOFTWARE DEFINED VEHICLES 3-0-0-3

Course Objectives

1. To provide an overview on the integration of software in vehicle systems.
2. To develop application of software-defined networking and IoT technologies.
3. To familiarize in the role of software in autonomous driving technology, intelligent transportation systems, and its challenges.

Course Outcomes

CO	CO Description
CO1	Describe the various software architecture applicable for automotive systems.
CO2	Analyse the application of software-defined networking, IoT technologies, and data analytics in SDVs.
CO3	Visualize various communication protocols to be implemented in SDVs.
CO4	Develop strategies for addressing security, privacy, and regulatory challenges in software-defined vehicles.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	1	2	1	1	3
CO2	1	2	1	1	3
CO3	1	2	1	1	3
CO4	1	2	1	1	3

Skills acquired

Compare traditional vehicles and electric vehicles, Environmental and economic considerations of electric mobility, Fundamentals of Software-Defined Systems

Unit 1 14 hours

Definition and characteristics of software-defined systems-Role of software in shaping modern technologies-Software-defined networking and its application in electric mobility- Zonal Architecture Concepts: Centralized vs. Decentralized Architecture. Components of E&E Architecture: ECUs (Electronic Control Units), Networks (CAN, LIN, FlexRay, Ethernet)Electric Vehicle Architecture-Integration of software in electric vehicle architecture-Communication protocols and interfaces in EVs-Software in Power Management-Power electronics and control software-Optimization algorithms for energy efficiency.

Unit 2 17 hours

Connected Vehicles and IoT in Electric Mobility-Introduction to connected vehicle technologies-Internet of Things (IoT) applications in electric mobility-Data analytics and vehicle-to-everything (V2X) communication-Autonomous Driving and Software Control. Introduction to Cloud Computing: Definition, Characteristics, Deployment Models (Public, Private, Hybrid), Service Models (IaaS, PaaS, SaaS).Overview of Major Cloud Service Providers: Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform (GCP), and others. Overview of High-Performance Computing (HPC) in Automotive Systems. Requirements and challenges in automotive HPC: Safety, Reliability, Performance, Power Efficiency. Middleware for Embedded Systems: Communication Protocols (CAN, SPI, I2C), Message Brokers, Remote Procedure Calls (RPC). Edge Computing in Embedded Systems: Concepts, Architecture, Use Cases. Fundamentals of Application Development- Web Application Development- Application Architecture Patterns- Deployment and Distribution Strategies.

Unit 3 14 hours

Sensor fusion and Safety- Sensor fusion and data processing algorithms-Path planning and decision-making algorithms-Real-time operating systems for SDVs -Challenges and Future Directions-Security and privacy concerns in software-defined electric mobility Security and Privacy Considerations: data encryption, secure communication protocols, user authentication.-regulatory and standardization challenges- Automotive Safety Standards (ISO 26262), Data Protection Regulations (GDPR, CCPA). Over-the-Air (OTA) Updates, Predictive Maintenance, Personalized Services. Emerging trends and future developments.

Text Books / References

1. James Larminie and John Lowry, "Electric Vehicle Technology Explained", Willey, 2012.
2. Tom Denton, "Autonomous Vehicle Technology: A Guide for Technicians and Engineers", Cengage Learning, 2022.
3. Thomas D. Nadeau and Ken Gray, "Software-Defined Networking", O'Reilly Media, 2023.

24AT614 ADVANCED DRIVER ASSISTANCE SYSTEM 2-0-3-3

Course Objectives

1. To provide knowledge on fundamental concepts, terminologies, and design considerations in autonomous vehicle systems.
2. To make students' understand state estimation and localization techniques including least squares, Kalman filters, and sensor fusion for accurate positioning of autonomous vehicles.
3. To familiarize students with neural networks and deep learning techniques, focusing on feedforward neural networks and convolutional neural networks (CNNs)
4. To familiarize in motion planning algorithms and techniques, including driving missions, occupancy grids, and path planning algorithms

Course Outcomes

CO	CO Description
CO1	Analyse and evaluate the safety considerations and design aspects in autonomous vehicle systems.
CO2	Implement state estimation and localization algorithms using sensor data, demonstrating proficiency in techniques such as Kalman filtering and sensor fusion for accurate vehicle positioning.
CO3	Designing and training neural networks for various tasks in autonomous driving, including object detection and segmentation, utilizing deep learning frameworks.
CO4	Develop and implement motion planning algorithms and techniques, including path planning and obstacle avoidance through simulation.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3		1	1	3
CO2	2	2		1	3
CO3	2	2	1	3	3
CO4	3	2	1	3	3

Skills acquired

Designing and implementing state estimation algorithms, neural networks for perception tasks, motion planning algorithms, and utilizing sensor data for object detection and tracking in autonomous vehicle systems.

Unit 1 10 hours

Introduction to ADAS: Introduction – Terminology, Design consideration, Safety assessment. Commonly used hardware, main components of software stack, Vehicle modelling and control, safety frameworks and current industry practices. State Estimation and Localization – Least squares – Vehicle localization sensors – GPS and IMU – Extended Kalman filter, unscented Kalman filter – LIDAR scan matching, iterative Closest Point Algorithm – Multiple sensor fusion for vehicle state estimation and localization.

Unit 2 10 hours

Feedforward neural networks: – Review of Deep Learning, Multilayer Perceptron, Optimization, Stochastic Gradient Descent, Back propagation - Review of Convolutional Neural Networks (CNN): Architecture, Convolution/Pooling layers – Understanding and Visualizing CNN. Visual Perception – Visual Perception - Pinhole camera model, intrinsic and extrinsic camera calibration, monocular and stereo vision, projective geometry - CNNs for 2 D Object detection, Semantic segmentation.

Unit 3 10 hours

Motion Planning: - Driving Missions, Scenarios, and Behaviour, Motion Planning Constraints, Objective Functions for Autonomous Driving, Hierarchical Motion Planning - Occupancy Grids, Populating Occupancy Grids from LIDAR Scan Data, Occupancy Grid Updates, High Definition Road Maps. ACC, AEBs, LDWS, LKA Creating a Road Network Graph, Dijkstra's Shortest Path Search, A* Shortest Path Search, Motion Prediction, Map-Aware Motion Prediction, Time to Collision. UNECE, GSR, Indian regulations.

Lab Content **45 hours**

1. Utilizing a monocular camera for object detection.
2. Employing LIDAR for object detection.
3. Utilizing RADAR for object detection.
4. Object tracking via LIDAR.
5. Object tracking employing stereo camera technology.
6. Measuring object distances using LIDAR.
7. Utilizing RADAR for object distance measurement.
8. Employing Stereo camera technology for object distance measurement.
9. Camera-based lane identification.
10. Optical character recognition applied for detecting traffic signs

Text Books / References

1. Lipson, H & Kurman, M, Driverless: Intelligent Cars on the Road Ahead, MIT Press, 2020
2. Dan Simon, "Optimal State Estimation: Kalman, H∞, and Nonlinear Approaches", John Wiley & Sons, 2012
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016
4. David A. Forsyth, Jean Ponce, " Computer Vision: A Modern Approach", Pearson, 2023
5. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016
6. S. Thrun, W. Burgard, and D. Fox, "Probabilistic robotics", MIT Press, 2010

24AT615 VEHICLE DYNAMICS AND SIMULATION 2-0-3-3

Course Objectives

1. To make the student understand the vehicle dynamics parameters
2. To interpret system Modelling equation.
3. To make the student to simulate various driving conditions to analyse its parameters
4. To model the block diagram to solve the system engineering problems using soft tools.

Course Outcomes

CO	CO Description
CO1	Analyse and formulate the dynamic models for vehicle systems
CO2	Evaluate the performance characteristics of vehicle dynamics under various driving conditions
CO3	Demonstrate the vehicle motion and analyze the vehicle response for various driving conditions
CO4	Simulate various driving conditions and experimental validation

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	2	1
CO2	3	2	1	2	2
CO3	3	1	1	2	1
CO4	3	2	1	2	2

Skills acquired

Analyse the vehicle response for various driving conditions and formulate the fundamental of vehicle dynamics. Simulation of various driving conditions and experimental validation

Unit 1 10 hours

Vehicle Dynamics Introduction and Steering - Load distribution – calculation of CG of a vehicle – Effect of CG on vehicle performance.- Basic equation of Acceleration, Brake performance. Acceleration - Power-Limited, traction-limited- Steering system - The Steering Linkages and settings- Steering System Forces and Moments - Steering System Models – steering ratio, under steer/over steer-Problems. Influence of Front-Wheel Drive - Four-Wheel Steer. Rollover - Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, transient Rollover. Experiment with the Measurement steering wheel (MSW) and Wheel pulse transducer.

Unit 2 14 hours

Brake and Tire forces: Braking Performance- Basic Equations - Braking Forces – Brake Proportioning, efficiency-Problems – Experiment with the Pedal force Transducer for evaluating the performance of vehicle body speed, wheel speed, tire longitudinal slip, and the stopping distance experienced by the vehicle. Tire Tractive and cornering Properties - Camber Thrust - Aligning Moment - Combined Braking and Corning - Conicity and Ply Steer - Tire Vibrations. Ride – Excitation sources - Vehicle Response Properties - Steady-State cornering – low speed turning and High speed cornering-problems. Simulate tire conditions to study the tire inflation pressure, stiffness, friction levels.

Unit 3 6 hours

Aerodynamic forces on vehicle: Aerodynamic forces on ground vehicles - Wheel load - traction due to Aerodynamic forces - safety, performance characteristics –Problems-Three dimensional effects - Design features to reduce drag. Computational analysis and kinematic and force analysis of systems.

Lab Content **45 hours**

1. Homologation trials - Acceleration test,
2. Brake test,
3. Single lane change test,
4. Double lane change test.
5. Steering effort test.- Steering torque measurement-
6. Brake force measurement test- Gear shift effort test.
7. Pitch, Yaw and roll measurement (Road test & IPG Carmaker simulation).
8. Simulated Vehicle performance on road profile-creating and customizing the vehicle model to the requirement-Exercises using simulation tools (IPG Carmaker)
9. Modeling an Anti-Lock Braking System-Magic Formula based Tire Modelling (Matlab)

Text Books / References

1. Thomas D.Gillespie, “Fundamentals of Vehicle Dynamics”, SAE International Publication, 2017.
2. Popp, Karl, Schiehlen and Werner, “Ground Vehicle Dynamics”, Springer Publication, 2020.
3. Rao V.Dukkipati and Jian Pang, “Road Vehicle Dynamics”, SAE International Publication, 2008.
4. Richard Barnard, “Road Vehicle Aerodynamic Design”, Second Revised Edition, Mechaero Publishing, 2021.
5. Philip D Cha, James J Rosenberg and Clive L Dym, ‘Fundamentals of Modeling and Analyzing Engineering Systems”, Cambridge University, 2013.
6. Woods, Robert L., and Lawrence Kent L, “Modeling and Simulation of Dynamic Systems”, Prentice Hall, 2010.

24RM601 **RESEARCH METHODOLOGY** **P/F**

Course Objectives

To develop an understanding of the basic framework of research process
To identify various sources of information for literature review and data collection
To develop an understanding of the ethical dimensions of conducting applied research

Course Outcomes

CO	CO Description
CO1	Understand research problem formulation.
CO2	Analyse research related information.
CO3	Follow research ethics.
CO4	Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
CO5	Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
CO6	Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	2		
CO2	1	1	3		
CO3	1	1	2		
CO4	1		3		
CO5	1	1	2		
CO6	1	1	2		

Skills Acquired:

Carryout research in the field of interest, analyze, record and create report using soft tools and IPR.

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

Effective literature studies approaches, analysis Plagiarism, Research ethics.

Effective technical writing, how to write report, Paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Text Books / References

1. Michael P. Marder, Research Methods for Science, Cambridge University Press, 2011.
2. Shumway and Stoffer, Time Series Analysis and Its Applications, Springer, 2000.
3. C. R. Kothari, Research Methodology – Methods and Techniques, 2nd Edition, New Age International Publishers, 2004.
4. Donald H.McBurney, Research Methods, Thomson Learning, 2006.
5. Leslie Lamport, LaTeX: A Document Preparation System, Addison Wesley, 1994
6. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”. Aspen Law & Business; 6 edition July 2012

ELECTIVE STREAMS – SOFTWARE DEFINED VEHICLES

24AT731 CONTROL SYSTEMS FOR AUTONOMOUS VEHICLES 3-0-0-3

Course Objectives

1. To familiarize with the mathematical modelling of control systems
2. To make students' understand the concept of stability of control systems
3. To provide knowledge on design control strategies for various applications.

Course Outcomes

CO	CO Description
CO1	Develop the mathematical model of the physical systems
CO2	Analyse the response and stability of the closed and open loop systems
CO3	Analyse the control systems using Model based design.
CO4	Develop and analyse state space models and multivariable control systems
CO5	Design controllers based on stability and performance requirements

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	1	2	1	1	2
CO2	1	2	1	1	2
CO3	1	2	1	1	2
CO4	1	2	1	1	2
CO5	1	2	1	1	2

Skills acquired

Design, develop, analyse control systems for autonomous vehicle

Unit 1 **15 hours**

Introduction to System modelling: Importance of control system in Electrical vehicle, Study of control architecture in Electric vehicle, Systems models and their classifications, principles used in modelling of systems. Continuous time systems modelling - 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**

Model based control approach for Electric Vehicle: Introduction to P, PI & PID Controller, and Internal Model Control (IMC) Design, Introduction to Model based control system design for Electric Vehicle. 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.

Unit 3 **15 hours**

Stability aspects of control systems: Stability concept, Stability definition in the sense of Lyapunov, Stability of continuous time Linear systems, Lyapunov stability theorem, Vehicle stability analysis. Applications of control techniques in Traction control, Vehicle Control, Electric power steering control.

Text Books / References

1. Hui Zhang and Dongpu Cao and Haiping Du, “Modelling, Dynamics and Control of Electrified Vehicles”, WP Publishing, Elsevier, 2018
2. Norman S. Nise, “Control Systems Engineering”, 8th Ed., John Wiley & Sons, 2019.
3. Georg Rill, Abel Arrieta Castro, “Road Vehicle Dynamics,: Fundamentals and Modelling with MATLAB”, CRC Press, 2020.
4. Rajesh Rajamani, “Vehicle Dynamics and Control”, Springer, Second Edition, 2012
5. Wuwei Chen, Hansong Xiao, Qidong Wang, Linfeng Zhao and Maofei Zhu, “Integrated Vehicle Dynamics and Control”, Wiley, First Edition, 2016
6. Norman S. Nise, Control Systems Engineering, 8th Ed., John Wiley & Sons, 2019.

24AT732 REAL-TIME OPERATING SYSTEMS 2-0-3-3

Course Objectives

1. To make students' understand the fundamental concepts, features, and classification of real-time systems.
2. To explore real-time scheduling algorithms, including clock-driven and priority-driven approaches, to manage system tasks effectively.
3. To comprehend the necessity of an RTOS kernel services.
4. To familiarize with RTOS services designed to efficiently manage real-time environments.

Course Outcomes

CO	CO Description
CO1	Identify the basic features and categorizations of real-time systems.
CO2	Examine various scheduling algorithms used in real-time systems.
CO3	Describe various services provided by the RTOS kernel.
CO4	Develop real time automotive applications using RTOS.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	3
CO2	1	2	1	1	3
CO3	1		1	1	2
CO4	1	2	1	3	3

Skills acquired

Analysing and optimizing real-time system performance, implementing scheduling algorithms, and utilizing real-time operating system functionalities

Unit 1 **10 hours**

Introduction to real-time operating systems - Tasks - Semaphores - Message Queues – Exceptions and Interrupts - Timer Services – I/O Subsystem – Memory Management.

Unit 2 **10 hours**

Characteristics and Classification of real-time systems - Features to Real-time Systems - Performance measures for real time systems - Processor Utilization Factor – Real-time Scheduling: Clock –Driven, Priority-Driven - Multiprocessor scheduling.

Unit 3 **10 hours**

RTOS System Level Functions – Task Service Functions – Semaphore Related Functions – Queue Related Functions – Time Delay Functions – Memory Allocation Related Functions.

Case Study on RTOS based Antilock Braking System (ABS) and Advanced Driver Assistance Systems (ADAS).

Lab Content **45 hours**

1. Study and analysis of the performance of the real-time systems.
2. Compare and evaluate Real-Time Scheduling Algorithms using Simulation tool.
3. Real-Time Data Acquisition and Processing for Automotive Temperature Sensors using an RTOS Framework.
4. Multitasking of Automotive Sensor Monitoring and Actuator Control using RTOS.
5. Exchange the data between Tasks using RTOS IPC Services.
6. Task synchronization using RTOS synchronization primitives.
7. RTOS Memory Management in Automotive Systems.
8. Simulate an RTOS-based ABS System.

Text Books / References

1. Douglas Wilhelm Harder, Jeff Zarnett, Vajih Montaghami, Allyson Giannikouris, Jürgen Sauermann, Melanie, “A Practical Introduction to Real-time Operating Systems (RTOS)”, University of Waterloo ,2020.
2. Brian Amos, "Hands-On RTOS with Microcontrollers: Building Real-Time Embedded Systems Using FreeRTOS, STM32 MCUs, and SEGGER Debug Tools", Packt Publishing Ltd, Second Ed., 2020
3. Colin Walls, “Building a Real-Time Operating System: RTOS from the Ground Up”, Newnes, First Ed., 2011.
4. Qing Li, Caroline Yao, “Real-Time Concepts for Embedded Systems” First Ed., CRC Press, 2010.
5. K.V.K.K.Prasad, “Embedded Real-Time Systems: Concepts, Design & Programming”, Dreamtech press, First Ed., 2005.

24AT733 AUTOMOTIVE USER EXPERIENCE(UX) DESIGN 3-0-0-3

Course Objectives

1. To make students' understand the significance of User Experience (UX) in the automotive industry and its evolution.
2. To provide foundational knowledge in human-centered design principles and their application in automotive UX.
3. To familiarize various components of automotive UX design including infotainment systems, navigation interfaces, and emerging technologies like AR and AI.
4. To inculcate skills in usability testing, iterative design processes, and incorporating user feedback in automotive UX design.

Course Outcomes

CO	CO Description
CO1	Demonstrate an understanding of the importance of UX in the automotive industry and its historical evolution.
CO2	Apply human-centered design principles and basic concepts from cognitive psychology to automotive UX design challenges.
CO3	Design and evaluate interfaces for infotainment systems, navigation controls, and emerging technologies such as AR displays and AI integration in automotive environments.
CO4	Conduct usability testing, gather user feedback, and iterate designs to improve the overall user experience in automotive applications**.**

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	2	3
CO2	3	2	1	2	3
CO3	3	2	1	2	3
CO4	3	2	1	2	3

Skills acquired

Design user-friendly automotive interfaces and conducting usability testing while applying human-centered design principles.

Unit 1 **15 hours**

Overview of Automotive User Experience- Importance of UX in Automotive Industry Evolution of Automotive UX Design-Human-Centered Design Principles- Basics of Human-Computer Interaction- Cognitive Psychology in UX Design-Design Thinking Process, Usability Principles and Guidelines.

Unit 2 **15 hours**

Infotainment Systems Design: Navigation and Map Interfaces-Audio and Entertainment Controls. Touchscreen and Gesture-Based Controls-Haptic Feedback Integration-Voice Recognition Systems. Augmented Reality (AR) Displays-Heads-Up Displays (HUDs)-Integration of AI and Machine Learning in Automotive UX.

Unit 3 **15 hours**

UX Design: Usability Testing in Automotive Environments-Gathering and Analyzing User Feedback Iterative Design Process in Automotive UX. Autonomous Vehicles and UX Design-Connectivity and IoT in Automotive Design-Emerging Technologies and Their Impact on Automotive UX.

Text Books / References

1. Andreea Niculescu, " Automotive User Interface Design: Creating Interactive Experiences in the Car", Wiley , 1st Edition,2023
2. Andreas Riener, Andreu Vall, and Stephen Brewster, " Human-Centered Design for Automotive User Interfaces: Creating Compelling User Experiences", Springer, 1st Edition, 2022
3. Martin Schmidt, "Usability Testing in Automotive Design: Methods, Tools, and Best Practices", CRC Press, 1st Edition, 2023
4. Emily Chen, "Autonomous Vehicles: The Future of Transportation User Experience", O'Reilly Media, 1st Edition, 2024
5. Priyanka Saha, "Designing Interfaces in Public Settings: Understanding the Role of the Spectator in Human-Computer Interaction", Springer, 2020

24AT734 **VEHICULAR COMMUNICATION** **3-0-0-3**

Course Objectives

1. To introduce emerging technologies in vehicular communication systems and networks.
2. To provide insights on challenges and design considerations of V2X communications at various networking layers.
3. To impart knowledge on various aspects of a vehicular communication network.

Course Outcomes

CO	CO Description
CO1	Understand technologies and system architecture of vehicular networks.
CO2	Familiarise on the various vehicular communication protocols and standards.
CO3	Analyze vehicular communication technologies for safety and infotainment applications.
CO4	Implement vehicular communication networks using simulation Tools.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3		1	1	3
CO2	2		1	1	3
CO3	3	2	1	1	3
CO4	3	2	1	1	3

Skills acquired

Analysis and design of vehicular communication networks models for vehicular applications.

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.

Text Books / 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 Adhoc Networks”, Springer, 2010.

24AT735 CYBERSECURITY FOR AUTOMOTIVE SYSTEMS 3-0-0-3

Course Objectives

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

Course Outcomes

CO	CO Description
CO1	Apply the fundamental principles behind cryptography and security
CO2	Implement the concepts of public key cryptography for different use cases.
CO3	Acquire knowledge on encryption techniques.
CO4	Analyse various protocols for network security.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	1				3
CO2	1				3
CO3	1				3
CO4	1	1			3

Skills acquired

Acquire fundamentals including encryption techniques, cryptographic protocols, and privacy measures for various networks, gaining skills in symmetric and asymmetric encryption, digital signatures, authentication, and privacy preservation.

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

Functions and code schemes:-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. Block chain for automotive security – vehicle data safety – Immutable Decentralized technology – transparency and security.

Text Books / References

1. William Stallings, “Cryptography and Network Security”, 8th Ed., Pearson, 2021
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.

24AT736 **MULTI SENSOR DATA FUSION** **3-0-0-3**

Course Objectives

1. To provide knowledge on the fundamental concepts of data fusion processes, including various models, configurations, and architectures used in integrating multiple data sources.
2. To familiarize probabilistic data fusion techniques such as Maximum Likelihood, Bayesian methods, Maximum Entropy methods, and Recursive Bayesian methods.
3. To provide knowledge in implementing and utilizing Kalman filtering theory for data fusion, including nonlinear Kalman filtering, information filtering, H∞ filtering, and multiple hypothesis filtering.
4. To familiarize advanced data fusion methods including handling missing measurements, utilizing possibility theory and Dempster-Shafer Method etc.

Course Outcomes

CO	CO Description
CO1	Design data fusion systems using various probabilistic methods, including Maximum Likelihood estimation, Bayesian inference, and Maximum Entropy methods.
CO2	Apply Kalman filtering theory for data fusion tasks, including understanding its theoretical foundations, implementing nonlinear Kalman filtering techniques, and utilizing information filtering and multiple hypothesis filtering approaches.
CO3	Handle complex data fusion scenarios such as missing measurements, utilizing possibility theory and Dempster-Shafer Method for uncertainty management, and employing ANN-based decision fusion techniques.
CO4	Evaluate the performance of data fusion systems using Monte Carlo methods, understanding the Joint Directors of Laboratories (JDL) process, and reviewing algorithms for object refinement

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1		3
CO2	2		1	1	3
CO3	3	2	1	1	3
CO4	3	2	1	2	3

Skills acquired

Proficiency in integrating and analyzing multiple data sources through probabilistic methods, Kalman filtering, and advanced fusion techniques and algorithms.

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 Methods: 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 and Evaluation: 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.

Text Books / References

1. Martin Liggins II, David Hall, and James Llinas, "Multi-Sensor Data Fusion: Theory and Practice", CRC Press. - 2nd Ed., 2022,
2. Hassen Fourati, "Advances in Multi-Sensor Data Fusion: Algorithms and Applications" CRC Press, 1st Ed., 2023.
3. H. B. Mitchell , "Multi-Sensor Data Fusion: An Introduction", CRC Press, 2nd Ed.,2020,
4. David L. Hall and James Llinas, "Multi-Sensor Data Fusion: A Review of the State-of-the-Art", Springer, 2nd Ed. 2021.
5. David L. Hall, James Llinas, "Principles of Multi-Sensor Data Fusion" Wiley-IEEE Press 2nd Ed., 2019.
6. Jitendra R Raol, "Data Fusion Mathematics: Theory and Practice", CRC Press, 2016.

ELECTRIC AND HYBRID VEHICLES

24AT741 DESIGN OF BATTERY PACK AND THERMAL MODELLING 2-0-3-3

Course Objectives

1. To provide knowledge on battery chemistries like Li-ion and Li-polymer and their applications.
2. To familiarize electrochemical processes, series/parallel configurations, and module assembly.
3. To introduce students on BMS roles, communication protocols, and safety features in battery packs.
4. To evaluate electrical, thermal, and mechanical design, safety standards, and testing procedures.

Course Outcomes

CO	CO Description
CO1	Identify and analyze battery chemistries for diverse applications.
CO2	Design and assemble battery packs considering voltage, current, and thermal management.
CO3	Implement BMS for safety and efficiency, including communication protocols.
CO4	Test battery pack assembly, thermal evaluation, and performance testing.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1		3
CO2	2	2	1	1	3
CO3	3	2	1	1	3
CO4	3	2	1	1	3

Skills acquired

Designing and assembling battery packs, including considerations for voltage, current, and thermal management including safety and communication protocols.

Unit 1 **10 hours**

Battery chemistry: Overview of battery chemistries (Li-ion, Li-polymer, etc.)-Types of batteries and their applications-Basics of electrochemical processes in batteries-Series and parallel configurations-Module and pack assembly-Cell interconnections and busbars.

Unit 2 **10 hours**

Role of BMS in battery packs: Communication protocols and data acquisition-BMS algorithms for balancing and protection. Electrical Design Considerations-Voltage and current requirements-Selection of battery cells and configuration-Power electronics for charging and discharging. (10 hours)

Unit 3 **10 hours**

Design and Testing: Thermal Design-Heat generation in batteries-Thermal management strategies-Cooling and heating systems for battery packs. Mechanical Design and Enclosure-Packaging and enclosure design-Vibration and shock considerations-Mounting and securing battery packs-Safety Protocols and Standards-Overview of safety standards (UL, IEC, etc.)-Safety features in battery packs-Emergency protocols and fault detection. Testing and Validation-Prototyping and testing procedures-Performance evaluation and optimization-Reliability testing and durability assessment.

Lab content **45 hours**

1. Introduction to Battery Pack Assembly and Disassembly
2. Comparison of Battery Chemistries
3. Performance Testing of Battery Packs
4. Thermal Behaviour Analysis of Battery Packs
5. Optimization of Battery Pack Configuration
6. Safety Considerations in Battery Pack Handling

Text Books / References

1. W.J. Zhang and X. Yu, “Battery Thermal Management Systems for Electric Vehicles", Springer, 2018
2. Christopher D. Rahn and M. Saiful Islam, "Battery Systems Engineering", CRC Press, 2013.
3. H.A. Kiehne and E. Di Valentin, "Battery Technology Handbook" CRC Press, 2013.
4. A. Pesaran, M. Keyser, and Y. Kim, "Thermal Management of Electric Vehicle Battery Systems", SAE International, 2011.

24AT742 **BATTERY MANAGEMENT SYSTEM** **2-0-3-3**

Course Objectives

1. To provide knowledge on lithium-ion cell types, datasheet reading, dimensions, maximum charge/discharge currents, and lifecycle considerations.
2. To provide knowledge on battery pack design focusing on electrical, mechanical, and thermal aspects for optimization.
3. To familiarize battery management systems, including standalone and master-slave configurations, and their functionalities.
4. To make students' understand state-of-charge (SOC) and state-of-health (SOH) estimation techniques using various methodologies.

Course Outcomes

CO	CO Description
CO1	Interpret lithium-ion cell datasheets effectively for informed decision-making.
CO2	Design efficient battery packs considering performance and safety requirements.
CO3	Configure and implement robust battery management systems, including cell balancing and protection mechanisms.
CO4	Apply SOC and SOH estimation techniques to evaluate battery health and performance accurately.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1		3
CO2	2	2	1	1	3
CO3	3	2	1	1	3
CO4	3	2	1	1	3

Skills acquired

Interpreting lithium-ion cell datasheets and designing efficient battery packs, as well as configuring robust battery management systems and evaluate battery performance.

Unit 1 **10 hours**

Introduction: Lithium ion cell types, datasheet reading, dimensions, maximum charge and discharge currents, life cycle etc – Lithium ion cell characteristics: Dependence of cycle life, state of charge (SoC) and state of health (SoH) on various parameters – Battery pack design: Electrical, mechanical and thermal considerations.

Unit 2 **10 hours**

Battery management system – Introduction – Types: Standalone and master - slave configuration – Functionality: Simple circuits for cell balancing(active and passive balancing), Protection: Cell Undervoltage Protection, Cell Overvoltage Protection, Overcurrent in Charge Protection, Overcurrent in Discharge Protection – High side FETs and Low side FETs, Under temperature in Charge Protection, Under temperature in Discharge Protection, Overtemperature in Charge Protection, Overtemperature in Discharge Protection, Precharge and Predischarge circuits.

Unit 3 **10 hours**

SOC and SOH estimation techniques: Open circuit volage tracking, Impedance tracking and Extended Kalman Filter - Commercially available battery monitors and protectors: Analog Devices LTC3300 – X and LT8584 and Renesas ISL94216A – Standards: AIS – 038 and AIS – 156.

Lab Content

1. Introduction to BQ – Studio software and Master Slave BMS
2. Accessing register map of BQ79606EVM via BQ – Studio.
3. Introduction to register configuration of BQ79606 monitor.
4. Configuration of measurement frequency, modes of operation and cell count.
5. Configuration of temperature measurement, communication channel type and clock.
6. Configuration of Over_X and Under_X registers or BQ79606 monitor.

Text Books / References

1. John Warner, "The Handbook of Lithium-Ion Battery Pack Design: Chemistry, Components, Types and Terminology", Elsevier 2015
2. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2002
3. Datasheets: LTC3300 – X, ISL94216A
4. Standards: AIS – 038, AIS – 156
5. BQ79606A – Q1 Evaluation module user guide
6. BQ79606A – Q1 Datasheet
7. https://www.ti.com/lit/ug/slou471e/slou471e.pdf?ts=1705051471748&ref_url=https%253A%252F%252Fwww.ti.com%252Ftool%252FBQ79606EVM-897
8. https://www.ti.com/lit/ds/slusdq4/slusdq4.pdf?ts=1705051477267&ref_url=https%253A%252F%252Fwww.ti.com%252Ftool%252FBQ79606EVM-897

24AT743 **CHARGING INFRASTRUCTURE** **3-0-0-3**

Course Objectives

1. To make students' understand the fundamentals of electric vehicle (EV) systems, including their benefits, charging modes, and types of EV supply equipment.
2. To classify and analyze charger standards and classifications based on charging levels, plug types, and communication protocols.
3. To impart knowledge on various types of AC-DC and DC-DC converters used in EV chargers.
4. To provide knowledge on protocols and communication methods in charging infrastructure.

Course Outcomes

CO	CO Description
CO1	Demonstrate a comprehensive understanding of EV systems, including their components, benefits, and charging infrastructure challenges.
CO2	Analyze and classify charger standards and classifications based on regional differences, charging modes, and plug types.
CO3	Design, model, and implement various AC-DC and DC-DC converters used in EV chargers.
CO4	Evaluate EMI/EMC considerations in EV charger design, including identifying sources of noise, measuring EMI/EMC spectrum, and designing filters

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	3
CO2	3	2	1	2	3
CO3	3	2		2	3
CO4	3	2	2	1	3

Skills acquired

Designing and implementing AC-DC and DC-DC converters for electric vehicle chargers, including modulation techniques and closed-loop control.

Unit 1 **12 hours**

Introduction: introduction to EV systems, EV benefits, battery charging modes, types of EV supply equipment (EVSE), components of EV battery chargers, charging infrastructure challenges Charger Classification and standards: classification based on charging levels (region-wise), modes, plug types, standards related to: connectors, communication, supply equipments, EMI/EMC. (12 hours)

Unit 2 **16 hours**

AC-DC Converter: types of AC-DC converters; working principles, modulation, design, and closed loop control of power factor correction converters (PFC): Boost type PFC, Totem-pole PFC, active front-end converter, three-phase PFCs; working principles, modulation, design, and closed loop control of single-stage AC-DC converters; G2V, V2X operations. DC-DC Converter: Types of DC-DC converter used for EV chargers; working principles, modulation, design, modelling and closed loop control of dual active bridge, LLC converter, high frequency magnetics, soft-switching criteria.

Unit 3 **17 hours**

Protocols and communication: Open charge point protocol (OCPP), Open System Interconnection-Layer-Model (OSI), adapted PWM signal based low level communication, PLC based high level communication, CAN communication, testing methodology for EV battery chargers and EVSE. EMI/EMC considerations: sources of EMI, differential mode noise, common mode noise, LISN, measuring of EMI/EMC spectrum, design of DM filters, CM filters- Case-studies on Delta, Hella on-board chargers. (17 hours)

Text Books / References

1. Tom Denton, “Automotive Electrical and Electronic Systems”, 5th Edition, Routledge, 2018
2. Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press., 2021
3. Robert W. Erickson, and Dragan Maksimovic “Fundamentals of Power Electronics”, 3rd ed., Springer, 2020
4. L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India, 2012.
5. Mohan N., Underland T.M. and Robbins W.P., “Power Electronics – Converters, Applications and Design”, 3rd Ed., Wiley India. 2008.

24AT744 ENERGY MANAGEMENT IN ELECTRIC AND HYBRID VEHICLES 3-0-0-3

Course Objectives

1. To introduce electric and hybrid vehicle architectures, battery technologies, and powertrain impacts.
2. To familiarize in modeling techniques, simulation tools, and control algorithms for energy storage systems.
3. To inculcate various optimization methods and energy management strategies to improve vehicle performance.
4. To introduce industry practices, innovations, and future trends in energy management for electric and hybrid vehicles.

Course Outcomes

CO	CO Description
CO1	Understand electric and hybrid vehicle concepts, battery technologies, and powertrain implications.
CO2	Apply modeling, simulation, and control techniques to analyze energy storage systems.
CO3	Implement optimization methods and energy management strategies for improving vehicle performance.
CO4	Follow industry practices, innovations, and future trends in energy management for electric and hybrid vehicles.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1	1	3
CO2	3	3	1	1	3
CO3	3	2	1	1	3
CO4	3	2	1	1	3

Skills acquired

Modelling, simulation, and analysis of energy storage systems in electric and hybrid vehicles.

Unit 1 15 hours

Hybrid Vehicle Architecture: Introduction to various electric and hybrid vehicle architectures - battery technologies utilized in these vehicles, encompassing different battery chemistries, performance metrics, and the significance of battery management systems (BMS) - Powertrain architectures and their impact on energy efficiency.

Unit 2 15 hours

Modelling techniques for energy storage systems: Simulation tools for analysing battery performance and behaviour - Case studies and practical applications in energy storage modelling - Control algorithms for optimizing energy flow and efficiency - Regenerative braking systems and energy recovery - State-of-charge (SoC) and state-of-health (SoH) estimation.

Unit 3 15 hours

Optimization methods for improving vehicle range and efficiency: Energy management strategies for different driving conditions and scenarios - Integration of predictive and adaptive control algorithms for optimal energy usage- Industry practices and innovations in energy management for electric and hybrid vehicles - Emerging trends and future directions in the field.

Text Books / References

1. Simona Onori, Lorenzo Serrao, “Hybrid Electric Vehicles Energy Management Strategies” , Springer Publications, 2nd edition, 2019.
2. Sheldon S. Williamson, “Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles” , Springer Publications, 2016.
3. Christopher D. Rahn and Chao-Yang Wang, "Battery Systems Engineering", Wiley Publications, 2013.

24AT745 **FUEL CELL TECHNOLOGY** **3-0-0-3**

Course Objectives

1. To make students' understand the thermodynamics underlying different types of fuel cells and their applications.
2. To familiarize in energy conversion efficiency of fuel cells, identifying and mitigating irreversible losses.
3. To introduce students' on modeling approaches to comprehend loss and degradation mechanisms in fuel cells.
4. To evaluate the suitability of fuel cells for automotive applications.

Course Outcomes

CO	CO Description
CO1	Model the various types of fuel cells
CO2	Analyse the performance of the Fuel cells
CO3	Assess the performance requirements and decide on the control strategies
CO4	Apply the knowledge on Fuel cells for Automotive applications

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	2	2
CO2	2	2	1	2	2
CO3	3	2	1	3	2
CO4	2	2	1	2	2

Skills acquired

Energy efficiency analysis, modelling approaches, degradation mechanisms assessment, drive train design and power system design for various applications in fuel cell technology.

Unit 1 **13 hours**

Fuel Cells: Types of fuel cells and their application – Thermodynamics, Energy conversion efficiency of fuel cells – Irreversible losses – Modelling approach – loss mechanism - Degradation mechanism and their lifetime – Fuel cells for automotive applications - PEM – polymer membrane – chemical, Mechanical degradation, catalyst, impurities.

Unit 2 **16 hours**

Types and Storage of Hydrogen: Operating principles of fuel cells – Electrode potential and current voltage curve – Fuel and oxidant consumption – Fuel cell system characteristics – Fuel cell technologies – Various types of fuel cell and operating characteristics – Fuel supply – Hydrogen storage – Compressed, cryogenic liquid and metal hydride storage – Hydrogen production – Steam, POX and Autothermal reforming – Non-Hydrogen Fuel cells.

Unit 3 **16 hours**

Fuel cell drive train design: Configuration, Control strategies, Parametric design, Motor Power Design,- Power design of the fuel Cell system –Design of the power and energy capacity – Design examples for various power requirements and applications– Fuel cell propulsion and hybrid powertrains -Fuel cell vehicles – Layout and basic analysis – Future concepts.

Text Books / References

1. MehrdadEhsani, Yimin Gao, Ali Emadi. - 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles' CRC Press, 2021
2. Viktor Hacker, Shigenori Mitsushim,"Fuel cells and Hydrogen From Fundamentals to Applied Research"x Elsevier, 2018
3. Bent Sorenson, Giuseppe Spazzafumo, "Hydrogen and Fuel Cells: Emerging Technologies and Applications", Acad Presses, 3rd edition.2010.
4. Corbo.P, "Hydrogen Fuel Cells for Road Transportation", Springer London Ltd., Springer, 2016.

24AT746 **HYBRID ELECTRIC VEHICLES** **3-0-0-3**

Course Objectives

1. To comprehend the principles and characteristics of hybrid electric drive-trains
2. To introduce the concept of energy flow and efficiency in hybrid electric vehicles
3. To compare energy management strategies in hybrid and electric vehicles
4. To teach design principles for the development of hybrid electric vehicles

Course Outcomes

CO	CO Description
CO1	Assess various hybrid drive-train topologies, fuel efficiency, energy flow dynamics, and optimization strategies in hybrid electric vehicles
CO2	Analyze and compare different energy management strategies employed in hybrid electric vehicles
CO3	Apply applying principles of power and mass computations, component sizing, and drivetrain configuration in designing hybrid electric vehicles.
CO4	Design and optimize HEVs by using principles of power and mass computations, component sizing, and drivetrain configuration.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	3	2
CO2	2	2	1	3	2
CO3	3	2	1	3	2
CO4	3	2	1	3	2

Skills acquired

HEV energy optimization strategies, Range extension, HEV Control system, Drive cycle evaluation, Drive selection

Unit 1 **16 hours**

Introduction to Hybrid Electric Vehicle: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, Energy Flow Analysis: fuel efficiency analysis, Range extender, optimization and hybridness, Battery power and electric motor power, Mild or micro hybrid features, Plug-in hybrid, All-wheel drive hybrid, Fuel economy analysis and comparison for a BEV/HEV Vehicle with a Fixed Gear Ratio, Energy Consumption, Power Output, Efficiency.

Unit 2 **16 hours**

Design of HEV Drive train: Power and Mass Computations for Initial Vehicle Sizing, Power Requirements, Acceleration Power, Grade-Climbing Power, Vehicle Mass, Component Sizing, Techniques to enhance hybrid performance, Drive cycle and its detailed analysis, Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems, Switch Technology Selection, Drive Train Configuration, Drivetrain Control Technique, Traction Torque Control Approach.

Unit 3 **13 hours**

Control System for HEVs & Energy Management: Hybrid ECU and its classification, Fuzzy Logic Based Control System, Elementary of Control Theory, Overview of Control System and Electronic Control Unit (ECU), Control Area Network, Control Variables. Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Text Books / References

1. Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, Second Ed., 2021.
2. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz M. Ebrahimi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles”, CRC Press, Third Ed., 2018.
3. James Larminie, John Lowry, “Electric Vehicle Technology”, Wiley, Second ed., 2012.
4. Tom Denton, “Electric and Hybrid Vehicles”, Routledge, Third Ed., 2024

GENERAL ELECTIVES

24AT751 NOISE, VIBRATION AND HARSHNESS 2-0-3-3

Course Objectives

1. To inculcate measurement and analysis techniques for vehicle noise and vibration
2. To familiarise with the application of NVH refinement in vehicles and their systems
3. To introduce advanced techniques in reduction of NVH
4. Enable to use simulation tools to analyse the signals for reducing noise.

Course Outcomes

CO	CO Description
CO1	Analyse vibrations of SDOF, MDOF and Continuous systems, vibration measurement and analysis.
CO2	Acquire vibration and noise signals and evaluate them by applying various techniques including modal analysis.
CO3	Apply Principles of NVH refinement in Vehicles and their systems – power train, chassis, body, suspension, etc.,
CO4	Evaluate acoustic materials and apply them for noise reduction.
CO5	Perform NVH simulation, Statistical Energy Analysis, Acoustic Holography, beam forming, etc.,

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	2	2
CO2	3	2	1	2	2
CO3	3	3	1	2	2
CO4	3	3	1	2	2
CO5	3	3	1	2	2

Skills acquired

Measurement and analysis of Vehicle Noise and vibration, Signal Processing and analysis including Random signals, modal analysis, vibration and noise reduction techniques.

Unit 1 10 hours

Introduction to Automotive NVH-Fundamentals of vibrations –Vibration of Single degree of freedom, Multi degrees of freedom - Vehicle vibration measurement and analysis Fundamentals of acoustics, Vehicle noise measurement, Noise Standards, Types of Signals, Signal conditioning and processing, Data Acquisition Systems, Analysis and presentation of data Ride Comfort – Sound Quality and psychoacoustics –Sound Quality Metrics, Subjective–objective correlation –Squeak and Rattle-Vibration isolation and Transmission.

Unit 2 10 hours

Signal Analysis: Fourier series – Fourier Integrals –- Discrete Fourier Transforms – Fourier and Laplace Transforms - Filters - Windowing - Time Sampling and Aliasing - Random signal processing and analysis -Theory of modal analysis - Methods for performing modal analysis, Modal analysis of components, systems and vehicles Vehicle NVH refinement –Vehicle Development process - Target setting and Benchmarking. (10 hours)

Unit 3 10 hours

Refinement of Power train systems, Chassis and Suspension and Body –Vibro-acoustics – Aerodynamic noise and its refinement–Aeroacoustics Simulation methods in Automotive NVH – FEM, BEM, MBD, CFD, TPA, SEA, Vibro and Aeroacoustics, Cross functional optimization–Acoustic shielding and sound packages – Acoustic materials and their characterization - Active and semi-active noise control and their control systems and applications-Special issues related to EHV NVH .

Lab Content **45 hours**

1. Sound Power evaluation using SPL measurements- ISO 3744
2. Motor SPL measurement as per SAE
3. Modal Testing and analysis
4. Signal Analysis using FFT
5. Demonstration of inverse square law
6. Demonstration of the effect of sound absorbing and insulating materials
7. Noise source identification by masking method
8. Motor vehicle pass-by noise- IS 3028/ISO 362
9. Motor vehicle Stationary noise (tail pipe noise) - ISO 10399
10. Sound Quality analysis - Jury Rating, Metrics and its correlation
11. Vibration measurement and Modal analysis

Text Books / References

1. Xu Wang, "Vehicle Noise and Vibration Refinement", CRC Press Publication, 2020.
2. J.M. KrodkiewskI, "Mechanical Vibration" Univ of Melbourne, 2018
3. Kihong Shin and Joseph K. Hammond "Fundamentals of Signal Processing for Sound and Vibration Engineers", Johe Wiley, 2021.
4. S.S.Rao, " Mechanical Vibrations", Prentice- Hall, 2011

24AT752 **AUTOMOTIVE SAFETY SYSTEMS** **3-0-0-3**

Course Objectives

1. To introduce vehicle passive and active safety systems
2. To familiarize the various safety equipment and systems in automotive safety
3. To introduce on the energy based approach employed in automotive crash modelling and analysis
4. To teach the bio-mechanics modelling and simulation tests for automotive collision

Course Outcomes

CO	CO Description
CO1	Analyse the vehicle structures for crashworthiness to meet vehicle crash test requirements..
CO2	Examine pedestrian safety requirements and apply ergonomic concepts to vehicle interior design
CO3	Identify injury severity index and requirements of crash dummies.
CO4	Recommend the requirements for automotive lighting, warning devices, bumper and vehicle seats.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	2	1	1	2	2
CO2	2	2	1	0	2
CO3	2	1	1	2	2
CO4	2	1	1	0	2

Skills acquired

Apply ergonomic concepts to vehicle interior design, Lighting and testing methods for safety.

Unit 1 **10 hours**

Statistics of accidents: Accident investigation and analysis. Active and passive safety. Characteristics of vehicle structures, Optimization of vehicle structures for crashworthiness. Design of safety and crash structures. Types of crash / roll over, Regulatory requirements for crash testing– Instrumentation requirements for crash testing.

Unit 2 **17 hours**

Pedestrian Safety and Ergonomics: Importance of Ergonomics in Automotive safety - Anthropometry - Locations of controls .Human impact tolerance- Determination of Injury thresholds, Severity Index. Vehicle Safety systems - Survival space requirements, Restraint systems used in automobiles -safety belts-Types of safety belts and its comparison, Head restraints, Air bags - Use of energy absorbing systems - Impact protection from steering controls.

Unit 3 **18 hours**

Seats and Automotive Lightings: Design of seats - Damageability criteria in bumper designs - safety glass and their requirements, rearward field of vision in automobiles - Warning devices- under run protection devices. Collision warning and avoidance systems. Comfort and convenient systems. Automotive Lighting and Light Signaling Devices - Automotive lamps, design, construction, material, and performance - Light signaling devices .Emerging technologies: Gas Discharge lamp, LED, Adoptive Front Lighting System (AFLS), Daylight Running Lamps (DRL). Safety standards ISO 26262.

Text Books / References

1. Johnson W and Mamalis A.G., "Crashworthiness of Vehicles", Mechanical Engineering Publications, 2012.
2. Matthew Huang, "Vehicle Crash Mechanics", CRC Press,2022
3. Olson L. P., "Forensic Aspects of Driver Perception and Response", Lawyers and Judges, 5th edition 2019.
4. Daniel J Helt, "Recent Development in Automotive Safety Technology", SAE International Publication, 2004.
5. Robert Bosch, "Safety Comfort and Convenience Systems", Wiley, 2007.

24AT753 **VEHICLE BODY ENGINEERING** **3-0-0-3**

Course Objectives

1. To introduce the types, construction of car, bus and truck bodies
2. To provide insights on body mechanisms, trim and materials
3. To familiarise on applications of structural analysis to the car bodies

Course Outcomes

CO	CO Description
CO1	Evaluate the different Construction Methodologies of the Vehicle Bodies
CO2	Apply the Regulations for vehicle body construction
CO3	Select the Body Materials and Trims
CO4	Perform structural analysis of the vehicle body structure

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	1	1
CO2	3	1	1	1	1
CO3	3	3	1	1	1
CO4	3	3	1	1	1

Skills acquired

Basic understanding of Vehicle bodies, their construction, regulations and materials. Structural analysis of vehicle body structure

Unit 1 **15 hours**

Car Body Details: Types: compact, hatch-back, saloon, convertibles, limousine, estate car, racing and sports car. Car body construction; design criteria, prototype making, Body In white, creating the inner panels, underfloor panels, detailing of class A surfaces (Flanges, seating, hemming. Electric vehicle body design.

Structural Analysis of the Body: Loads experienced by the body structure under various vehicle operating conditions, Simple Structural Surfaces (SSS) method and its application to various types of car bodies, the effect of internal stresses, design synthesis, etc.

Unit 2 **15 hours**

Bus Body Details: Types: mini bus, single decker, double-decker, two level and articulated bus. Bus body layout; floor height, engine location, entrance and exit location, seating dimensions. Constructional details: frame construction, double skin construction, types of metal sections used, Conventional and integral type construction, Bus Body Code and Regulations. Code for Truck Cabs, truck Bodies and trailers.

Bus and Truck Body Manufacturing techniques. Indian Bus and Truck body building scenario and the way forward.

Unit 3 **15 hours**

Commercial Vehicle Details: Types of body; flat platform, drop side, fixed side, tipper body, tanker body, Light commercial vehicle body types. Dimensions of driver's seat relation to controls. Driver's cab design. BODY MATERIALS, TRIM AND MECHANISMS: Steel sheet, timber, plastic, GRP, properties of materials; Corrosion, anticorrosion methods. Selection of paint and painting process. Body trim items. Body mechanisms. Born electric Vehicle-body types and materials.

Text Books / References

1. Lorenzo Morello, Lorenzo Rosti Rossini, Giuseppe Pia, Andrea Tonoli, “The Automotive Body, Vol 1 Components Design, Vol. 2: System Design” Springer science, 2011.
2. Jason C. Brown, A. John Robertson and Stan T. Serpento, “Motor Vehicle Structures: Concepts and Fundamentals”, Butterworth-Heinemann, 2002.
3. Janusz Pawłowski, “Vehicle Body Engineering, Business Books, 1969.
4. AIS 052: Code pf Practice for Bus Body Design and Approval, ARAI, Pune,2022
5. AIS 093: Code pf Practice for Construction and Approval of Truck Cab and truck Bodies, ARAI, Pune, 2022.

24AT754 AUTOMOTIVE TESTING AND VALIDATION 3-0-0-3

Course Objectives

1. To introduce testing and homologation which are essential for vehicle safety and compliance
2. To familiarise major testing bodies and key standards for vehicle approval.
3. To teach to measure engine power and emissions using dynamometers and analyzers.
4. To provide knowledge on testing and control vehicle noise and assess performance on various tracks.
5. To familiarise important automotive standards and safety regulations.

Course Outcomes

CO	CO Description
CO1	Apply fundamental knowledge to measure the emissions and calculate the vehicle performance with reference to standard reference conditions.
CO2	Apply various methods of testing to vehicles, prime movers, drivelines, components, and materials including emissions, EMI/EMC, fatigue, crash, etc.
CO3	Identify the testing procedures of evaluating the vehicle performance, road test and track test.
CO4	Understand standard procedures for vehicle certification and approval as per rules and regulations.
CO5	Interpret and understand various automotive testing standards

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3				
CO2	3	2	2	1	3
CO3	3	3	2		3
CO4	3	3	2	1	3
CO5	3		2	1	

Skills acquired

Testing of vehicles, prime movers, drivelines, components, and materials. Application of Measurement systems, Instrumentation, data acquisition and analysis systems

Unit 1 8 hours

Introduction to Testing and Homologation: Need for Vehicle testing and homologation, Vehicle testing organizations, Specification & Classification of Vehicles (including M, N and O layout), Homologation & its Types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks. Approval for Safety systems (Active & Passive).

Unit 2 12 hours

Laboratory Engine Testing: Measurement of BHP, IHP, Engine testing on dynamometers, different types of dynamometers hydraulic, eddy current etc., engine analyzers- for petrol and diesel engines, FIP calibrating and testing. Emission test for CO, HC, NOx, CO2, PM, etc. using exhaust gas analyzers, Spectroscopic methods, NDIR (Non Dispersive Infrared), FID (Flame Ionization Detector), chemiluminescent analyzers, Gas Chromatograph, Smoke meters. Emission testing on chassis dynamometers, Driving Cycles- USA, Japan, Euro and India. Test procedures – European driving cycles, Modified Indian Driving Cycle, SHED (Sealed Housing for. Evaporative Determination) Test on chassis dynamometers.

Unit 3 12 hours

NVH and Vehicle performance Testing: Standard noise measurement methods, Noise inside and outside the vehicle, sources of vehicle noise - intake and exhaust noise, combustion noise, mechanical noise, noise from auxiliaries, wind noises, transmission noises, brake squeal, structure noise and noise control methods. Pass by Noise testing method. Methods for evaluating vehicle performance - energy consumption in conventional automobiles, performance, and emission and fuel economy, Operation of full load and part load conditions. Gradability test, Turning circle diameter test, Steering Impact test, Steering effort test. Road and track testing:

Maximum speed and acceleration, brake testing, lane changing, handling and ride characteristics. Track testing on Multi Friction Braking Track, High Speed Track, Wet skid pad, Test slopes, External noise test track, Accelerated fatigue track, Water wade, Salt-water wade, and Gravel road and off road track, Dry handling circuit, Comfort track.

Unit 4 **13 hours**

Automotive Testing Standards: AIS testing standards, Euro Standards, SAE standards. ISO26262 standards for functional safety of electrical and/or electronic systems in automobiles- EMI/EMC/EMS testing and regulations- Safety and crash testing– Regulatory and NCAP tests – Injury criteria - Testing of EHVs. AIS Standards: AIS-008 (Installation requirements of lighting and light-signaling devices for motor vehicles having more than three wheels, trailer and semi-Trailer excluding agricultural tractor and special purpose vehicles), AIS-018:2001 (Automotive Vehicles - Speed limitation Devices – Specifications), AIS-037 (Procedure for Type Approval and establishing conformity of production for safety of critical components), AIS093 (Code of practice for construction and approval of truck cabs & truck bodies), AIS-003 (Automotive Vehicles - Starting Gradeability - Method of Measurement and Requirements), AIS-038 (Battery Operated Vehicles – Requirements for Construction and Functional Safety).

Text Books / References

1. Martyr and Plint, “Engine Testing – Theory and Practice”, Butterworth Heinemann, 2017.
2. Indian Standards (IS)
3. Automotive Industry Standards (AIS)
4. Raymond M. Brach and R. Matthew Brach, "Vehicle Accident Analysis and Reconstruction Methods", SAE International, 2011
5. Ulrich Seiffert and Lothar Wech, “Automotive Safety Handbook”, SAE International, 2013
6. CMVR, TAPS document, Indian Standards, AISs, ISOs, etc
7. ISO Standards, ICS: 43.020, 43.040, 43.100

24AT755 AUTOMOTIVE EMISSIONS AND CONTROL 3-0-0-3

Course objectives

1. To familiarize on pollution formation and its control technology in engines
2. To familiarize normal and abnormal combustion from pressure data and interpret its effect on engine performance.
3. To introduce fuel cells , H_2 storage and analyse its performance characteristics
4. To appraise the need for alternate fuels and methods to reduce emissions

Course Outcomes

CO	CO Description
CO1	Apply emission formation chemistry to analyse engine combustion
CO2	Recognize and identify selected modern emission systems to reduce emissions
CO3	Assess the performance requirements and decide on the control strategies
CO4	Select alternate fuels for controlling engine emissions

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	2			2	1
CO2	2	2		2	
CO3	2	3		2	2
CO4	2	3		2	

Skills acquired

Engine emissions modelling. Emission testing standards and procedures and Compare and analyse the performance of various Fuel cells and design a Fuel cell for Automotive application.

Unit 1 15 hours

Emission and its environmental impact -Exhaust emissions -Pollutant formation and chemistry- Nitrogen Oxides, Carbon Monoxide, Unburned Hydrocarbon, soot formation –Emission formation in CI and SI engines- Other emissions – Particulate, Crankcase, Evaporative, Refuelling, non-regulated emissions.

Unit 2 15 hours

Emissions Measurement and Testing: Procedures of two/three wheelers, light duty vehicles and Heavy-duty Vehicle Engines, Vehicle Emission Factors. In-use vehicles emission testing by RDE standards -Technology for Controlling Emissions for SI & CI Engine –In cylinder emission control technology- Exhaust Gas Treatment, Catalytic Converters, Thermal Reactors, Particulate Traps, EGR-SCR/SNR Technology.

Unit 3 15 hours

Combustion Diagnostic: Emission Control for Euro VI Technology - Emission Standards for Inspection and Maintenance Programs - Remote Sensing of Vehicle Emissions: Operating Principles, Capabilities, and Limitations. - Fuel Options for Controlling Emissions -Alternate fuels for controlling emissions–Indian drive cycle- European test cycle-Emission Standards.

Text Books / References

1. Colin Ferguson R., “Internal Combustion Engines”, John Wiley and Sons, 2018.
2. AsifFaiz, Christopher and S.Weaver, “Air Pollution from Motor Vehicles: Standards and Technologies for Controlling Emissions” World Bank Publication, 2000.
3. Heywood J B, “Internal Combustion Engine Fundamentals”, McGraw Hill International, 2017.
4. B.P.Pundir,“IC Engines: Combustion and Emissions”, Narosa,2nd ed., 2017

24AT756 COMPUTATIONAL FLUID DYNAMICS 2-0-3-3

Course Objectives

1. To introduce the basic governing equations and understand the basic properties of CFD.
2. To familiarise different discretization techniques and solving methods for improving accuracy.
3. To apply the knowledge while solving real time physical problems using simulation software.

Course Outcomes

CO	CO Description
CO1	Understand the classification of PDEs, governing equations and basic properties of computational methods.
CO2	Apply finite volume method to solve steady and unsteady diffusion, advection-diffusion problems.
CO3	Apply the various discretization methods, solution procedures and turbulence modelling to solve flow and heat transfer problems.
CO4	Apply the knowledge to interpret, solve and analyse engineering flow problems.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	1	1
CO2	3	3	1	1	1
CO3	3	3	1	1	1
CO4	3	3	1	1	1

Skills Acquired

Relate any physical problem in computational domain with right boundary conditions. Ability to analyze and interpret the results using CFD tools.

Unit 1 10 hours

Introduction to CFD: Classification of PDEs Simplifications, Building Blocks of CFD, Mathematical description of fluid flow and heat transfer-Conservation equations for mass, momentum, energy and chemical species-Classification of partial differential equations.

Unit 2 10 hours

Discretization techniques: Discretization techniques using finite difference and finite volume formulations. Steady and unsteady one-dimensional heat conduction, One dimensional steady convection and diffusion. Formulations for Convection-Diffusion problems, Upwinding, Explicit, Semi-implicit and Fully Implicit formulations for unsteady problems, Stability analysis. The concept of false diffusion, QUICK scheme, TVD schemes and flux limiter functions.

Unit 3 10 hours

Modelling: Discretization of Navier Stokes Equations, primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation, Introduction to Turbulence Modeling, spray and combustion modeling, Adaptive mesh refinement, Applications to practical problems using Open Foam/PyCFD and other commercial softwares.

Lab Content 45 hours

1. Simulation of Li-ion battery module
2. Simulation of hydrogen fuel cell
3. Simulation of IC engine using Ansys Forte
4. Simulation of one way fluid structure interaction
5. Simulation of single stage axial compressor using sliding mesh.
6. Simulation of heat transfer in electronic printed circuit boards and motors.

Text Books / References

1. Moukalled, F., Mangani, L., and Darwish, M. “The finite volume method in computational fluid dynamics. An Advanced Introduction with Open FOAM and Matlab”, 2021.
2. Versteeg, H.K., and Malalasekara, W, “An Introduction to Computational Fluid Dynamics”, The Finite Volume Method, 2017
3. Patankar, S.V., “Numerical Heat Transfer and Fluid Flow”, Hemisphere Publishing Corporation, 1980.
4. Anderson, D.A., Tannehill J.C., and Pletcher, R.H., “Computational Fluid Mechanics and Heat Transfer”, Hemisphere Publishing Corporation, 1984

24AT757 FINITE ELEMENT METHODS AND ANALYSIS 2-0-3-3

Course Objectives

1. Inculcate the knowledge to develop finite element programs to solve 1D and Multi-D problems using different FE procedures.
2. Inculcate the knowledge to formulate Strong, Weak, Galerkins, and Matrix forms to formulate and solve linear and non-linear multi-physics problems using the method of weighted residuals.
3. Utilize commercial finite element packages to model, solve, and analyze real-world industrial problems.

Course Outcomes

CO	CO Description
CO1	Develop different finite element procedures to solve simple 1D and 2D static problems like bars, beams, trusses, frames, etc
CO2	Formulate basic and higher order elements with applicability to 1D and Multi-D coordinate systems
CO3	Formulate and solve static and dynamic/transient problems in Solid Mechanics and Heat Transfer using the Method of Weighted Residuals
CO4	Estimate finite element assembly procedure by constructing ID, IEN, LM arrays
CO5	Develop finite element models to solve and analyse, static and dynamic, linear and non-linear multi-physics problems using a finite element package

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	1	1
CO2	3	3	1	1	1
CO3	3	3	1	1	1
CO4	3	3	1	1	1
CO5	3	3	1	3	3

Skills Acquired

Develop analytical and numerical models using the methodology of finite elements to solve and analyze linear and nonlinear problems involving single and multi-physics, and to effectively utilize commercial finite element packages for part and process modeling with applicability to real-world industrial problems.

Unit 1 10 hours

Fundamentals of governing equations: Governing equations in Solid Mechanics and Heat Transfer. Basic finite element procedures: Direct Stiffness Method, Principle of Minimum Potential Energy, Strong form, Weak form, Variational formulation, Weighted Residual Method - Galerkin formulation.

Unit 2 10 hours

Formulation of the finite element equations - Element types - Basic and higher order elements –1D, 2D, 3D coordinate systems. Finite elements in Solid Mechanics: Analysis of trusses, beams and frames, Plane stress, Plane strain and Axisymmetric elements, Isoparametric formulation and elements. Finite elements in Heat Transfer: Formulation and solution procedures in 1D and 2D problems – Steady State and Transient problems.

Unit 3 10 hours

Structural Dynamics: Formulation - Element mass matrices - Evaluation of Eigen values and Eigen vectors - Natural frequencies and mode shapes - Numerical time integration. Computer implementation of the Finite element method: Pre-processing, Element calculation, Equation assembly – Assembly Flowchart, ID, IEN, LM arrays, Solving – Numerical Integration – Gaussian Quadrature, Post processing – Primary and Secondary variables.

Lab Content **45 hours**

Static linear and non-linear analysis of thermo-mechanical and other coupled-physics problems, Problems involving discontinuous interactions, Modal analysis to capture natural frequencies and mode shapes, Steady-state dynamic analysis of problems involving harmonic loading and predict conditions for resonance, Transient dynamic analysis of mechanical and industrial processes like machining, rolling, extrusion-forming, punching, etc., Utilize non-default controls available in FE packages for specific applications, Develop & Run script files for simple problems without using GUI, Develop user-defined codes and plug-ins for specific applications.

Text Books / References

1. Thomas J. R. Hughes, "The Finite Element Method – Linear Static and Dynamic Finite Element Analysis", 2nd Ed., Dover Publications Inc, 2012.
2. Rao S. S., "The Finite Element Method in Engineering", Fifth Ed., Elsevier, 2022.
3. Daryl L. Logan, "A First Course in the Finite Element Method", Sixth Ed., Cengage Learning, 2016.
4. David V. Hutton, "Fundamentals of Finite Element Analysis", McGraw Hill, 2005.
5. Reddy J. N., "An Introduction to the Mathematical Theory of Finite Elements", Dover Publications, 2011.
6. Jacob Fish and Ted Belytschko, "A First Course in Finite Elements", Wiley Inter Science, 2007.
7. DS Simulia, "Abaqus Documentation", Abaqus version 6.16.

23HU601	**Career Competency I**	**L-T-P-C: 0-0-3-P/F**

Prerequisite:

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

Course Objectives:

- Help students transit from campus to corporate and enhance their soft skills
- Enable students to understand the importance of goal setting and time management skills
- Support them in developing their problem solving and reasoning skills
- Inspire students to enhance their diction, grammar and verbal reasoning skills

Course Outcomes:

CO1: Soft Skills - To develop positive mindset, communicate professionally, manage time effectively and set personal goals and achieve them.

CO2: Soft Skills - To make formal and informal presentations with self-confidence.

CO3: Aptitude - To analyze, understand and employ the most suitable methods to solve questions on arithmetic and algebra.

CO4: Aptitude - To analyze, understand and apply suitable techniques to solve questions on logical reasoning and data analysis.

CO5: Verbal - To infer the meaning of words and use them in the right context. To have a better understanding of the nuances of English grammar and become capable of applying them effectively.

CO6: Verbal - To identify the relationship between words using reasoning skills. To understand and analyze arguments and use inductive/deductive reasoning to arrive at conclusions and communicate ideas/perspectives convincingly.

CO-PO Mapping

PO/CO	PO1	PO2	PO3
CO1	2	1	-
CO2	2	1	-
CO3	2	1	-
CO4	2	1	-
CO5	1	2	-
CO6	2	2	-

Syllabus:

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

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. Emphasize the importance of avoiding the gap (assumption) in arguments/ statements/ communication.

Oral Communication Skills: Aid students in using the gift of the gab to improve their debating skills.

Writing Skills: Introduce formal written communication and keep the students informed about the etiquettes of email writing. Make students practise writing emails especially composing job application emails.

Aptitude

Numbers: Types, Power Cycles, Divisibility, Prime, Factors & Multiples, HCF & LCM, Surds, Indices, Square roots, Cube Roots and Simplification.

Percentage: Basics, Profit, Loss & Discount, and Simple & Compound Interest.

Ratio, Proportion & Variation: Basics, Alligations, Mixtures, and Partnership.

Averages: Basics, and Weighted Average.

Time and Work: Basics, Pipes & Cistern, and Work Equivalence.

Time, Speed and Distance: Basics, Average Speed, Relative Speed, Boats & Streams, Races and Circular tracks.

Statistics: Mean, Median, Mode, Range, Variance, Quartile Deviation and Standard Deviation.

Data Interpretation: Tables, Bar Diagrams, Line Graphs, Pie Charts, Caselets, Mixed Varieties, and other forms of data representation.

Equations: Basics, Linear, Quadratic, Equations of Higher Degree and Problems on ages.

Logarithms, Inequalities and Modulus: Basics

References

Soft Skills:

Communication and listening skills:

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

Assertiveness skills:

- Robert Bolton, Dorothy Grover Bolton, "People Style at Work..and Beyond: Making Bad Relationships Good and Good", Ridge Associates Inc., 2009
- John Hayes "Interpersonal skills at work", Routledge, 2003
- 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:

- Mark J Martinko, "Attribution theory: an organizational perspective", St. Lucie, 1995
- Miles Hewstone, "Attribution Theory: Social and Functional Extensions", Blackwell, 1983

Time management:

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

Verbal:

- Erica Meltzer, "The Ultimate Guide to SAT Grammar"
- Green, Sharon, and Ira K. Wolf, "Barron's New GRE", Barron's Educational Series, 2011
- Jeff Kolby, Scott Thornburg & Kathleen Pierce, "Nova's GRE Prep Course"
- Kaplan, "Kaplan New GRE Premier", 2011-2012
- Kaplan's GRE Comprehensive Programme
- Lewis Norman, "Word Power Made Easy", Goyal Publishers, Reprint edition, 1 June 2011
- Manhattan Prep, "GRE Verbal Strategies Effective Strategies Practice from 99th Percentile Instructors"
- Pearson- "A Complete Manual for CAT", 2013
- R.S. Aggarwal, "A Modern Approach to Verbal Reasoning"
- S. Upendran, "Know Your English", Universities Press (India) Limited, 2015
- Sharon Weiner Green, Ira K. Wolf, "Barron's New GRE, 19th edition (Barron's GRE)", 2019
- Wren & Martin, "English Grammar & Composition"
- www.bbc.co.uk/learningenglish
- www.cambridgeenglish.org
- www.englishforeveryone.org
- www.merriam-webster.com

Aptitude:

- Arun Sharma, "How to Prepare for Quantitative Aptitude for the CAT Common Admission Test", Tata Mc Graw Hills, 5th Edition , 2012
- Arun Sharma, "How to Prepare for Logical Reasoning for the CAT Common Admission Test", Tata Mc Graw Hills, 2nd Edition, 2014
- Arun Sharma, "How to Prepare for Data Interpretation for the CAT Common Admission Test", Tata Mc Graw Hills, 3nd Edition, 2015
- R.S. Aggarwal, "Quantitative Aptitude For Competitive Examinations", S. Chand Publishing, 2015
- R.S. Aggarwal, "A Modern Approach To Verbal & Non-Verbal Reasoning", S. Chand Publishing, Revised - 2015
- Sarvesh Verma, "Quantitative Aptitude-Quantum CAT", Arihant Publications, 2016
- www.mbatious.com
- www.campusgate.co.in
- www.careerbless.com

Evaluation Pattern

Assessment	**Internal**	**External**
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50
Pass / Fail		

*CA - Can be **presentations, speaking activities and tests.**

23HU611	Career Competency II	L-T-P-C: 0-0-3-1

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

Course Objectives:

- Help students to understand the importance of interpersonal skills and team work
- Prepare the students for effective group discussions and interviews participation.
- Help students to sharpen their problem solving and reasoning skills
- Empower students to communicate effectively by using the correct diction, grammar and verbal reasoning skills

Course Outcomes:

CO1: Soft Skills - To demonstrate good interpersonal skills, solve problems and effectively participate in group discussions.

CO2: Soft Skills - To write technical resume and perform effectively in interviews.

CO3: Aptitude - To identify, investigate and arrive at appropriate strategies to solve questions on arithmetic by managing time effectively.

CO4: Aptitude - To investigate, understand and use appropriate techniques to solve questions on logical reasoning and data analysis by managing time effectively.

C05: Verbal - To be able to use diction that is more refined and appropriate and to be competent in knowledge of grammar to correct/improve sentences

C06: Verbal - To be able to examine, interpret and investigate passages and to be able to generate ideas, structure them logically and express them in a style that is comprehensible to the audience/recipient.

CO-PO Mapping

PO/CO	PO1	PO2	PO3
CO1	2	1	-
CO2	2	1	-
CO3	2	1	-
CO4	2	1	-
CO5	1	2	-
CO6	2	2	-

Syllabus

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 team work 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

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: Practice closet tests that assess basic knowledge and skills in usage and mechanics of writing such as punctuation, basic grammar and usage, sentence structure and rhetorical skills such as writing strategy, organization, and style.

Aptitude

Sequence and Series: Basics, AP, GP, HP, and Special Series.
Geometry: 2D, 3D, Coordinate Geometry, and Heights & Distance.
Permutations & Combinations: Basics, Fundamental Counting Principle, Circular Arrangements, and Derangements.
Probability: Basics, Addition & Multiplication Theorems, Conditional Probability and Bayes' Theorem.
Logical Reasoning I: Arrangements, Sequencing, Scheduling, Venn Diagram, Network Diagrams, Binary Logic, and Logical Connectives, Clocks, Calendars, Cubes, Non-Verbal reasoning and Symbol based reasoning.
Logical Reasoning II: Blood Relations, Direction Test, Syllogisms, Series, Odd man out, Coding & Decoding, Cryptarithmetic Problems and Input - Output Reasoning.
Data Sufficiency: Introduction, 5 Options Data Sufficiency and 4 Options Data Sufficiency.
Campus recruitment papers: Discussion of previous year question papers of all major recruiters of Amrita Vishwa Vidyapeetham.
Miscellaneous: Interview Puzzles, Calculation Techniques and Time Management Strategies.

References

Soft Skills

Team Building

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

Verbal

- "GMAT Official Guide" by the Graduate Management Admission Council, 2019
- Arun Sharma, "How to Prepare for Verbal Ability And Reading Comprehension For CAT"
- Joern Meissner, "Turbocharge Your GMAT Sentence Correction Study Guide", 2012

- Kaplan, “Kaplan GMAT 2012 & 13”
- Kaplan, “New GMAT Premier”, Kaplan Publishing, U.K., 2013
- Manhattan Prep, “Critical Reasoning 6th Edition GMAT”
- Manhattan Prep, “Sentence Correction 6th Edition GMAT”
- Mike Barrett “SAT Prep Black Book The Most Effective SAT Strategies Ever Published”
- Mike Bryon, “Verbal Reasoning Test Workbook Unbeatable Practice for Verbal Ability, English Usage and Interpretation and Judgement Tests”
- www.bristol.ac.uk/arts/skills/grammar/grammar_tutorial/page_55.htm
- www.campusgate.co.in

Aptitude

- Arun Sharma, “How to Prepare for Quantitative Aptitude for the CAT Common Admission Test”, Tata Mc Graw Hills, 5th Edition, 2012
- Arun Sharma, “How to Prepare for Logical Reasoning for the CAT Common Admission Test”, Tata Mc Graw Hills, 2nd Edition , 2014
- Arun Sharma, “How to Prepare for Data Interpretation for the CAT Common Admission Test”, Tata Mc Graw Hills, 3nd Edition , 2015
- R.S. Aggarwal, “Quantitative Aptitude For Competitive Examinations”, S. Chand Publishing , 2015
- R.S. Aggarwal, “A Modern Approach To Verbal & Non-Verbal Reasoning”, S. Chand Publishing , Revised - 2015
- Sarvesh Verma, “Quantitative Aptitude-Quantum CAT” , Arihant Publications , 2016
- www.mbatious.com
- www.campusgate.co.in
- www.careerbless.com

Evaluation Pattern

Assessment	**Internal**	**External**
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**

22AVP103 Mastery Over Mind (MAOM) 1-0-2 2

1. Course Overview

Master Over the Mind (MAOM) is an Amrita initiative to implement schemes and organise university-wide programs to enhance health and wellbeing of all faculty, staff, and students (UN SDG -3). This program as part of our efforts for sustainable stress reduction gives an introduction to immediate and long-term benefits and equips every attendee to manage stressful emotions and anxiety facilitating inner peace and harmony.

With a meditation technique offered by Amrita Chancellor and world-renowned humanitarian and spiritual leader, Sri Mata Amritanandamayi Devi (Amma), this course has been planned to be offered to all students of all campuses of AMRITA, starting off with all first years, wherein one hour per week is completely dedicated for guided practical meditation session and one hour on the theory aspects of MAOM. The theory section comprises lecture hours within a structured syllabus and will include invited guest lecture series from eminent personalities from diverse fields of excellence. This course will enhance the understanding of experiential learning based on university's mission: "Education for Life along with Education for Living", and is aimed to allow learners to realize and rediscover the infinite potential of one's true Being and the fulfilment of life's goals.

2. Course Syllabus

Unit 1 (4 hours)

Causes of Stress: The problem of not being relaxed. Need for meditation -basics of stress management at home and workplace. Traditions and Culture. Principles of

meditation– promote a sense of control and autonomy in the Universal Human Value System. Different stages of Meditation. Various Meditation Models. Various practices of Meditation techniques in different schools of philosophy and Indian Knowledge System.

Unit 2 (4 hours)

Improving work and study performance. Meditation in daily life. Cultivating compassion and good mental health with an attitude of openness and acceptance. Research and Science of Meditation: Significance of practising meditation and perspectives from diverse fields like science, medicine, technology. philosophy, culture, arts, management, sports, economics, healthcare, environment etc. The role of meditation for stress and anxiety reduction in one's life with insights based on recent cutting-edge technology. The effect of practicing meditation for the wholesome wellbeing of an individual.

Unit 3 (4 hours)

Communications: principles of conscious communication. Relationships and empathy: meditative approach in managing and maintaining better relationships in life during the interactions in the world, role of MAOM in developing compassion, empathy and responsibility, instilling interest, and orientation to humanitarian projects as a key to harness intelligence and compassion in youth. Methodologies to evaluate effective awareness and relaxation gained from meditation. Evaluating the global transformation through meditation by instilling human values which leads to service learning and compassion driven research.

TEXT BOOKS:

1.Mata Amritanandamayi Devi, "Cultivating Strength and vitality," published by Mata Amritanandamayi Math, Dec 2019
2.Swami Amritaswarupananda Puri ,"The Color of Rainbow " published by MAM, Amritapuri.

REFERENCES:

1.Craig Groeschel, “Winning the War in Your Mind: Change Your Thinking, Change Your Life” Zondervan Publishers, February 2019

2.R Nagarathna et al, “New Perspectives in Stress Management “Swami Vivekananda Yoga Prakashana publications, Jan 1986

3. Swami Amritaswarupananda Puri “Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation”, August 2019
4. Swami Amritaswarupananda Puri “From Amma’s Heart - Amma’s answer to questions raised during world tours” March 2018
5. Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.
6. Mata Amritanandamayi Devi “Compassion :The only way to Peace:Paris Speech”, MA Center, April 2016.
7. Mata Amritanandamayi Devi “Understanding and collaboration between Religions”, MA Center, April 2016.
8. Mata Amritanandamayi Devi “Awakening of Universal Motherhood: Geneva Speech” M A center, April 2016.

3. Evaluation and Grading

Internal			External	Total
Components	Weightage		Practical (attendance and class participation) 60%	100%
Quizzes(based on the reading material)	20%	40%		
Assignments (Based on webinars and lecture series)	20%			

4. Course Outcomes (CO)

CO1: Relate to the causes of stress in one’s life.
CO2: Experiment with a range of relaxation techniques
CO3: Model a meditative approach to work, study, and life.
CO4: Develop appropriate practice of MA-OM technique that is effective in one’s life
CO5: Inculcate a higher level of awareness and focus.
CO6: Evaluate the impact of a meditation technique

***Program Outcomes (PO) (As given by NBA and ABET)**

PO1: Engineering Knowledge
PO2: Problem Analysis
PO3: Design/Development of Solutions
PO4: Conduct Investigations of complex problems
PO5: Modern tools usage
PO6: Engineer and Society
PO7: Environment and Sustainability
PO8: Ethics
PO9: Individual & Team work
PO10: Communication
PO11: Project management & Finance
PO12: Lifelong learning

CO – PO Affinity Map

P O/ C O	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
CO 1	3	3	3	2		-	2	3	-	3	-	3	-	-	-
CO 2	3	3	3	2	2	_	2	3	3	3	-	3	-	-	-
CO 3	3	3	2	2	2	2	2	3	3	3	-	3	-	-	-
CO 4	3	3	3	2	-	2	3	3	3	3	-	3	-	-	-
CO 5	3	2	2	2	-	2	-	3	2	2	-	2	-	-	-
CO 6	3	2	2	2	3	2	_	3	2	2	-	2	-	-	-

22ADM501 **Glimpses of Indian Culture** **2 0 1 P/F**

Objective: Love is the substratum of life and spirituality. If love is absent, life becomesmeaningless. In the present world, if love is used as the string to connect the beads of values, Life becomes precious, rare, and beautiful like a fragrant blossom. Values are not to be learnedalone. They must be imbibed into the inner spirit and put into practice. This should happen at the right time when you have vitality and strength when your hearts are open.

The present course in value education is a humble experience-based effort to lead andmetamorphosis the students through the process of transformation of their inner self towards achieving the best. Amma's nectarous words of wisdom and acts of love are our guiding principles. Amma's philosophy provides an insight into the vision of our optimistic future.

1. Invocation, Satsang, and Question-Answers
2. Values - What are they? Definition, Guiding Principles with examples Sharing own experiences
3. Values - Key to a meaningful life. Values in different contexts
4. Personality - Mind, Soul, and Consciousness - Q and A. Body-Mind-Intellect and the Inner psyche Experience sharing
5. Psychological Significance of samskara (with e.g. From Epics)
6. Indian Heritage and Contribution and Q and A; Indian Ethos and Culture
7. Self-Discipline (Evolution and Practice) – Q and A
8. Human Development and Spiritual Growth - Q and A
9. Purpose of Life plus Q and A
10. Cultivating self-Development, Self-effort, and Divine Grace - their roles – Q and A.
11. Vedanta and Creation - Understanding a spiritual Master
12. Dimensions of Spiritual Education; Need for change Lecture – 1; Need for Perfection Lecture – 2
13. How to help others who have achieved less - Man and Nature Q and A, Sharing of experiences

REFERENCES

1. *Swami Amritaswaroopananda Puri - Awaken Children (Volume VII and VIII)*
2. *Swami Amritaswaroopananda Puri - Amma's Heart*
3. *Swami Ramakrishnanda Puri - Rising Along the Razor's Edge*
4. *Deepak Chopra - Book 1: Quantum Healing; Book 2: Alpha and Omega of God; Book 3: Seven Spiritual Rules for Success*
5. *Dr. A. P. J. Abdul Kalam - 1. Ignited Minds 2. Talks (CD)*
6. *Swami Ramakrishnanda Puri - Ultimate Success*
7. *Swami Jnanamritananda Puri - Upadesamritham (Trans: Malayalam)*
8. *Vedanta Kesari Publication - Values - Key to a meaningful life*
9. *Swami Ranganathananda - Eternal values for a changing society*
10. *David Megginson and Vivien Whitaker - Cultivating Self Development*
11. *Elizabeth B. Hurlock - Personality Development, Tata McGraw Hill*
12. *Swami Jagatatmananda - Learn to Live (Vol.1 and 2), RK Ashram, Mylapore*