M.TECH PROGRAMME

AUTOMOTIVE ENGINEERING

CURRICULUM & SYLLABUS

MECHANICAL ENGINEERING

AMRITA VISHWA VIDYAPEETHAM

DEEMED TO BE UNIVERSITY UNDER SECTION 3 OF THE UGC ACT, 1956

For students admitted from the year 2021 onwards

M. TECH – AUTOMOTIVE ENGINEERING

Department of Mechanical Engineering

About M.Tech - Automotive Engineering

This program is designed to enable the graduate engineers with appropriate background to specialize their careers towards Automotive Engineering and Automotive System Design. The objective of the program is to strengthen the ability of the student to solve complex technological problems and to develop skills that will prepare the student to work effectively in close collaboration within a multidisciplinary team and facilitates to develop R&D competency.

Besides mandatory core courses, a number of 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 intune with the objectives envisioned by the University. In addition the Industry 4.0 vision is implemented with a content of curricula into existing courses and new courses are designed in order to adapt this vision into the engineering education.

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	-	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:

PO1: An ability to 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: An ability to independently carry out research/investigation and development work to solve practical problems.

PO3: An ability to write and present a substantial technical report/document.

PO4: An Ability to analyze design and operating parameters of engines and its effect on emission characteristics.

PO5: An ability to use appropriate modern tools to simulate vehicle systems, analyse and predict system parameters to provide solutions.

PO6: An ability to design systems that are required for alternate power train, Electric and Hybrid vehicles with appropriate safety and environment considerations.

CURRICULUM

First Semester

Course Code	Type	Course	L	T	P	Cr
21AT600	FC	Applied Mathematics	3	0	3	4
21AT601	FC	Automotive Chassis and Transmission Systems	3	0	0	3
21AT602	FC	Internal Combustion Engines	3	0	0	3
21AT603	FC	Automotive Materials and Manufacturing	3	0	0	3
21AT611	SC	Automotive Electronics	3	0	0	3
21AT682	FC	Internal Combustion Engines Laboratory	0	0	3	1
21AT681	SC	Automotive Electronics Lab	0	0	3	1
21AT683	FC	Machine Learning with Python	0	0	3	1
21HU602		Career Competency I				P/F
21HU601	HU	Amrita Value Program				P/F
		Credits				**19**

Second Semester

Course Code	Type	Course	L	T	P	Cr
21AT612	SC	Vehicle Dynamics and Simulation	3	0	3	4
21AT613	SC	Emissions, Control and Fuel Cells	3	0	0	3
21AT614	SC	NVH and Refinement	3	0	0	3
21AT615	SC	Electric and Hybrid Vehicles	3	0	0	3
	E	Elective I	2	0	3	3
21AT684	SC	NVH Lab	0	0	3	1
21RM602	SC	Research Methodology	2	0	0	2
21HU603		Career Competency II	0	0	2	P/F
			Credits			**19**

Third Semester

Course Code	Type	Course	L T P	Cr
	E	Elective II	3 0 0	3
	E	Elective III	3 0 0	3
21AT798	P	Dissertation I		10
			Credits	**16**

Fourth Semester

Course Code	Type	Course	L T P	Cr
21AT799	P	Dissertation II		16
			Credits	**16**
			Total Credits	**70**

L- Lecture; T-Tutorial; P-Practical

FC- Foundation Core; SC- Subject Core; HU-Humanities; E-Electives; P- Dissertation; P/F-Pass/Fail

List of Courses

Foundation Core

21AT600	FC	Applied Mathematics	3 0 3	4
21AT601	FC	Automotive Chassis and Transmission Systems	3 0 0	3
21AT602	FC	Internal Combustion Engines	3 0 0	3
21AT603	FC	Automotive Materials and Manufacturing	3 0 0	3
21AT682	FC	Internal Combustion Engines Laboratory	0 0 3	1
21AT683	FC	Machine learning with Python Lab	0 0 3	1

Subject Core

21AT611	SC	Automotive Electronics	3 0 0	3
21AT612	SC	Vehicle Dynamics and Simulation	3 0 3	4
21AT613	SC	Emissions, Control and Fuel Cells	3 0 0	3
21AT614	SC	NVH and Refinement	3 0 0	3
21AT615	SC	Electric and Hybrid Vehicles	3 0 0	3
21AT681	SC	Automotive Electronics Lab	0 0 3	1
21AT684	SC	NVH Lab	0 0 3	1
21RM602	SC	Research Methodology	2 0 0	2

Elective I

Course Code	Course	L T P	Cr
21AT701	Computational Fluid Dynamics and Heat Transfer	2 0 3	3
21AT702	Finite Element Methods and Analysis	2 0 3	3

Electives II & III

Course Code	Course	L T P	Cr
21AT703	Testing and Validation	3 0 0	3
21AT704	Special Topics in Advanced Engineering Application	3 0 0	3
21AT705	Off-Highway Mobility	3 0 0	3
21AT706	Vehicle Body Engineering	3 0 0	3
21AT707	Automotive Safety Systems	3 0 0	3
21AT708	Automotive Infotronics	3 0 0	3

21AT709	Project Management	3 0 0	3
21AT710	Automotive HVAC, Cabin Comfort and Ergonomics	3 0 0	3
21AT711	MEMS for Automotive Applications	3 0 0	3
21AT712	Automotive Tribology	3 0 0	3

Project Work

Course Code	**Course**	**L T P**	**Cr**
21AT798	Dissertation I		10
21AT799	Dissertation II		16

SYLLABUS

21AT600 APPLIED MATHEMATICS 3- 0- 3- 4

Course Objectives:

1. Gain an understanding of errors in numerical methods and their propagation
2. Understand different numerical methods for the solution of algebraic equations
3. Analyse nonlinear ODEs using qualitative approach and to solve them using numerical methods
4. Recognize the three basic types of PDEs and to apply both analytic and numerical methods to the solution of important PDEs
5. To appreciate the power of abstraction through introduction and application of concepts like vector spaces, inner product spaces and linear transformations.

Course Outcomes:

CO1: Identify different errors and to quantify their propagation
CO2: Numerically solve single and system of nonlinear algebraic equations
CO3: Carry out qualitative analysis of nonlinear ODEs and to solve them numerically
CO4: Identify different types of PDEs and to solve them numerically
CO5: Find orthonormal basis for inner product spaces and to perform spectral decomposition of operators.

	PO1	**PO2**	**PO3**	**P04**	**PO5**	**PO6**
CO1	2	1	0	1	0	1
CO2	2	2	0	2	1	2
CO3	2	2	0	2	2	2
CO4	2	2	0	2	1	2
CO5	3	2	0	1	1	1

Skills acquired: Use algebraic skills essential for the study of systems of linear/nonlinear algebra, PDE, vector spaces, perform error analysis and use computation tools to enhance understanding.

Error Analysis: Accuracy and precision – Round-Off and Truncation errors, Taylors Series, Error propagation, Basic Applications: Interpolation and regression methods. Introduction to MATLAB and writing simple programs.Algebraic Equations: Bisection method, Fixed point iteration, Newton Raphson method, Secant method, Methods to solve systems of nonlinear equations, Basic applications.

Differential Equations: Ordinary differential equations, qualitative analysis, state space and linearisation, fixed points and their stability, basic examples. Euler's method, RungeKutta methods, Systems of equations, Basic examples including nonlinear simple endulum, vehicle models etc. Partial Differential Equations: Basic definitions. Model Equations: Elliptic, Parabolic and Hyperbolic PDEs. Solving PDEs Numerically - Elliptic, Parabolic and Hyperbolic Equations. Explicit methods, simple implicit methods, Crank-Nicholson method, Introduction to FEM.

Linear Algebra: Review of Matrix Algebra, systems of linear equations, matrices and matrix operations, Inverses, Determinants, Row reduction, Cramer's rule.– Vector Spaces – Sub Spaces – Linear Independence – Basis – Dimension – Null Space – Rank and Nullity – Inner Product – Orthogonality – Orthogonal Basis – Gram-Schmitt Process. Linear and inverse linear transformations.

TEXT BOOKS/REFERENCES:

1. C.F Gerald and P.O Wheatley, "Applied Numerical Analysis", Seventh Edition, Addison Wesley, 2009.
2. M.K.Jain, S.R.K. Iyengar and R.K.Jain, "Numerical Methods for Scientific and Engineering Computation", New Age International Publishers, Fifth Edition, 2007.
3. Howard Anton, and Chris Rorres "Elementary Linear Algebra: Applications", Tenth Edition, Tata Wiley, 2010.
4. Gilbert Strang, "Linear Algebra and Its Applications", Fourth Edition, Cengage, 2006.
5. E Kreyszig ,"Advanced Engineering Mathematics" E Kreyszig, John Wiley and Sons, Tenth Edition, 2015.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	10	-
Periodical 2	10	-
Continuous Assessment (Theory)*	15	-
Continuous Assessment (Lab)*	30	-
End Semester	-	35

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT601 AUTOMOTIVE CHASSIS AND TRANSMISSION SYSTEMS 3- 0- 0- 3

Course Objectives:

1. To make students familiar with the constructional details of chassis and brake system
2. To understand and the requirements to design clutch system.
3. To design the suspension system for various vehicles
4. To select proper steering systems, steering linkages and steering gear boxes and final drives

Course Outcomes:

CO1: Identify the loads, moments and stresses and design a braking system
CO2: Select the appropriate clutch type and design the clutch assembly for a typical vehicle
CO3: Select and design the transmission system and its components based on load and speed requirements of the vehicle
CO4: Design suspension systems for vehicles
CO5: Select the appropriate steering system and carry out its optimal design to minimise steering error

	PO1	PO2	PO3	P04	PO5	PO6
CO1	3		2	1		2
CO2	2	1				3
CO3	2	3		1		
CO4	2		3	1		
CO5	2	3	1			1

Skills Acquired: Analyze and improve Brake system , Electronic stability, Suspension system, Transmission

Chassis-Introduction to Chassis and its types.Braking System: Principles, Components.Hydraulic Systems, Hydraulic Valves and Switches, Brake Fluid and Lines Wheel Bearings - Drum and Disc Brakes. Parking Brake System design –Brake system layout design – Braking system parameters calculation based on vehicle configuration – Design of actuation system – design verification and checking the compliance with legislation.-Power Brake System - Regenerative Braking Systems, ABS Components and Operation - Electronic Stability Control Systems, Tires and Wheels - Tire Pressure Monitoring Systems - Suspension System Components and Operation, Front and rear suspension - Electronic Suspension Systems,.

Steering systems - Columns and Gears - Steering Linkage– Characteristics of steering geometry-Layout of steering systems - Power-Assisted Steering Operation, Drive Axle Shafts and CV Joints, Wheel Alignment Principles - Design features and standards of chassis systems. Basic Elements of Vehicle and Transmission Engineering - Selecting the Ratios - Overall Gear Ratio, Planetary gear systems-Multi-plate clutches - Dry Clutches – Wet clutches Dual clutches - Hydrodynamic Clutches and Torque Converters. Matching Engine and Transmission, traction diagram, Geared Transmission with Dry Clutch and torque converter..

Transmission: Basic Design Principles – Arrangement. Passenger Car Transmissions - Manual Passenger Car - Automated Manual Transmissions - Dual Clutch Transmissions - Automatic and

Hybrid Drives - Continuously Variable Transmissions. Final drives – axle drives - Differential Gears and Locking Differentials – hub drives. Gear shifting Mechanisms. Electronic Transmission Control

TEXT BOOKS/REFERENCES

1. Andrew Day, "*Braking of Road Vehicles*", Butterworth-Heinemann, 2014
2. *Harrer, Manfred, and Peter Pfeffer, eds. "Steering handbook"* Switzerland: Springer International Publishing, 2017.
3. Naunheimer H, Bertsche B, Ryborz J and Novak W, "*Automotive Transmissions*", Springer, 2011.
4. Abbot and Sheldon L, "*Automotive Power Trains: Clutch, Manual Transmission, Transaxle and Final Drive*", McGraw Hill, 1988.
5. Genta, Giancarlo ,Morello L, "*The Automotive Chassis Vol 1 - Component Design*"and"*The Automotive Chassis Vol 2 - System Design*", Springer, 2009.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT602 INTERNAL COMBUSTION ENGINES 3- 0- 0- 3

Course Objectives:

1: To acquire knowledge on thermo-chemistry of air-fuel mixture.
2: To analyse the engine performance characteristics by understanding the gas flows.
3: To apply engine concepts to design heat flow in engines.
4: To introduce newer combustion technology for engines

Course Outcomes:

CO1: Design engines with an understanding of thermo-chemistry.
CO2: Model gas flow behavior and predict performance of engines.
CO3: Optimally design heat flow in engines
CO4: Comprehend newer combustion technology and its requirement

	PO1	PO2	PO3	P04	PO5	PO6
CO1	2	3	2	3		
CO2	2	3	2			
CO3	2	3	2	3		
CO4	2	3	2			2

Skills Acquired: Understand engine combustion and to formulate engine design, power calculation and comprehend various combustion technology

Thermo chemistry of fuel-air mixtures, Engine Design and Operating Parameters- Properties of Working Fluids - Unburned Mixture Composition - Gas Property Relationships - Thermodynamic Relations for Engine Processes - Gas Exchange Processes . Flow through manifolds, turbocharging and supercharging Charge Motion within the Cylinder- Swirl, squish - Mixture formation, Ignition, Load Control. Combustion process, Power output calculations, Atmospheric conditions and corrections.

Combustion in Spark-Ignition Engines and Compression-Ignition Engines, Lubrication,Crevice flow, blowby,Prechamber flow, Cooling, Nature of engine heat transfer and its basic considerations, Parametric relationship of engine output with heat transfer,Convective and radiative heat transfer in engines; Heat transfer correlations in engines, Boundary layer model for in cylinder heat convection; Thermal loading and transient heat transfer through walls. Basic concepts of engine simulation, governing equations, simulation of various engine processes for SI and CI engines. Heat release calculations. Thermodynamic and Fluid mechanics based models

Advanced combustion technology- HCCI, PCCI, RCCI Engines, Lean burn engines-Cycles-Miller cycle, Atkinson cycle-Simulations.

TEXT BOOKS/REFERENCES:

1. Heywood J B, "*Internal Combustion Engine Fundamentals*", McGraw Hill International 2017.
2. Colin Ferguson R., "*Internal Combustion Engines*", John Wiley and Sons, 2015.
3. Gupta, Ashwani K., et al., eds. *Advances in IC Engines and Combustion Technology: Select Proceedings of NCICEC 2019*. Springer Nature, 2020.

4. Charles Fayette Taylor, "*The Internal Combustion Engine in Theory and Practice,Vol 1 &*2", MIT Press, 1995.
5. CarstenBaumgarten, "*Mixture Formation in IC Engines*", Springer, 2007.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT603 AUTOMOTIVE MATERIALS AND MANUFACTURING 3-0-0-3

Course Objectives:

1. To present a problem oriented in depth knowledge of automotive materials and manufacturing.
2. To apply knowledge of automotive materials and selection of material in the field.
3. To describe the integration of manufacturing and new technology applications in the automotive industry.

Course Outcomes:

CO1: Classify the materials used for automotive applications
CO2: Identify the appropriate manufacturing processes of automotive applications
CO3: Select the suitable materials for automotive applications
CO4: Develop new materials and process for advanced automotive applications

	PO1	PO2	PO3	P04	PO5	PO6
CO1	-					1
CO2	1	1			1	1
CO3	1	1		1		1
CO4	2	3	1			1

Skills Acquired: Advanced materials, Heat treatment,noval materials, Casting, Forging. Hybrid materials, Analyse the behaviour of advanced materials and processes used for the parts

Introduction to common engineering materials, Iron-carbon phase diagram: eutectic, pearlitic, eutectoid reactions, classifications of steels and cast irons, Strengthening mechanisms: Effect solid solutions, Heat treatment, surface engineering, High Strength Low Alloy Steels (HSLA), advanced high strength steels, copper base alloys, Ultra-light weight metallic materials: Aluminium base alloys, magnesium base alloys, titanium alloys, typical properties of alloy grades, methods of identification of alloy grades, standards for automotive materials. manufacturing considerations for various lightweight automotive structures

Primary, secondary and advanced processes for automotive applications - Casting, forging, forming, fusion and solid state joining, powder metallurgy, 3D printing, instruction to unconventional and advanced metallurgical processes, Effect of alternate fuels on materials.
Selection, processing and design of materials for auto components : cylinder block, Cylinder head, piston, piston ring, connecting rod, crank shaft, crank case, cam, cam shaft, engine valve, gear wheel, clutch plate, axle, bearings, chassis, spring, shock absorber, propeller shaft, body panel, radiator, brake pads, fuel tank and seats.

Advanced polymers and composites: Properties and applications for automotives, elastomers, silicon rubbers. Polymer & carbon Fiber reinforced plastics, metal matrix /composites and nano-composites. Other Materials - Electrical insulating materials. Gaskets, automotive glasses, Sound insulating materials, Protective coating materials, bulletproof glasses etc. Automotive ceramics-Novel material for automotive applications, Graphene, Battery materials and technology. Futuristic technology and material for automotive applications, hybrid materials- processes and applications.

Case studies on Li-ion battery, polymer composites and sensor materials. Chemical reactions between fuel and metals, environmentally induced degradation.

TEXT BOOKS/ REFERENCES:

1. Michel F Ashby, "Material Selection in Mechanical Design", 4th edition, Elsevier, 2011.
2. Michel F Ashby, "Material and Design: The Art and Science of Material Selection in Product Design", Butterworth Heinemann, 2008.
3. John Mortimer, "Advanced Manufacturing in the Automotive Industry" Springer, 1997.
4. Harry Peck, "Design for Manufacturing", Pitman Publications, 1983.
5. Cantor B, Johnston, Colin Grant and Patrick, "Automotive Engineering: Lightweight, Functional and Novel Materials", Taylor & Francis Ltd, 2008.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT611 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:

CO1: Choose suitable sensors and actuators for automotive applications
CO2: Design control systems for drive by wire systems
CO3: Make use of controllers and sensors for implementation of simple automotive electronic hardware
CO4: Understand the working of starting, charging system and vehicle networks

	PO1	PO2	PO3	P04	PO5	PO6
CO1	3	2	2	1	1	1
CO2	3	3	2	2	1	1
CO3	3	2	2	2	1	1
CO4	3	2	2	-	1	-

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

Introduction to Electronic systems in Automotives – 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. Hardware implementation example of simple automotive systems using Sensors, Controller, Actuators etc.

Battery- types and maintenance, Alternators in vehicles, Starting motor systems, Electrical circuits and wiring in vehicles, vehicle network and communication buses – Digital engine control systems, Introduction to automotive controllers, On-Board Diagnostics (OBD). Introduction to electric vehicles and BMS.

TEXT BOOKS/REFERENCES:

1. Bosch,"*Automotive Electrics and Automotive Electronics. System and components ,Networking and Hybrid drive*", Sixth edition, Springer 2021
2. NajamuzZaman , " *Automotive Electronics Design Fundamental''* first edition, Springer 2015.
3. William B. Ribbens, "*Understanding Automotive Electronics*" Eighth Edition, Butterworth - Heinemann, 2017

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT682 INTERNAL COMBUSTION ENGINES LAB 0-0-3-1

Course Objectives:

1. To understand the working principle of IC Engine components and its operation

2. To test the engine by mounting on the test bed and do performance and emission analysis of IC engines using various fuels.
3. To acquire engine data to analyze the effect of engine performance on various engine parameters

Course Outcomes:
CO1: Understand the working principle of IC Engine Operation
CO2: Conduct performance and emission analysis of IC engines fuelled with Gasoline, Diesel and alternate fuels
CO3: Analyze the effect of engine performance on various design parameters
CO4: Conduct combustion study using pressure data

	PO1	PO2	PO3	P04	PO5	PO6
CO1			2		2	
CO2	2	3	2	3		1
CO3	2	3		3	2	
CO4	1	3	2	3	2	

Skills Acquired: Conduct performance and emission analysis of IC engines fuelled with Gasoline, Diesel and alternate fuels and Analyze its effect on engine parameters.

Performance and emission study on SI/CI Engine using 5 mode test cycle for constant speed engines, 13 mode and 8 mode test cycle, -Types of Dynamometers -Performance, combustion and Emission study on the effect of various fuel injection pressures, split injection, EGR and timing on engine-Performance, combustion and emission characteristics study with alternative fuels-effect of preheated air and fuel on performance - HIL-Experiments on single and multi-cylinder SI/CI to find friction power-Combustion analysis of IC engines by acquiring P-Ɵ data.

Self study-Disassembly and assembly of IC Engines) Valve timing and port timing diagram-Heat balance test- Engine-Installation with dynamometer including data acquisition system-Air handling and Coolant circuits.

Evaluation Pattern:

Evaluation Components	Internal	External
Continuous Assessment (Lab)*	70	-
End Semester	-	30

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,

21AT681 AUTOMOTIVE ELECTRONICS LAB 0-0-3-1

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 interface the sensors with the controllers for automotive applications.

Course Outcomes:

CO1: Select suitable sensors and actuators for automotive applications
CO2: Understand the control systems for X by Wire' systems
CO3: Make use of controllers and sensors for implementation of simple automotive electronic hardware
CO4: Understand the working of PID controller and vehicle networks

	PO1	PO2	PO3	P04	PO5	PO6
CO1		2	2	1	1	
CO2	2		2			1
CO3	1	2	2	1		
CO4	1		2			

Skills Acquired: Design and simulation of simple electric circuits using MATLAB and programming MK40DX256 for automotive applications using CodeWarrior

Voltage and Current Divider Circuit – RLC circuit(MATLAB simulation) –Passive filter circuits –Diode circuits–rectifiers, clippers, clampers-Zener diode-OPAmp Circuits – Inverting and Non – Inverting amplifiers – Adder – PID controller (MATLAB simulation)

MK40DX256 - IO Configuration, Timer, PWM- DC motor speed control, ADC, DAC, Periodic Timer Interrupt, sensor interfacing to MK40DX256 via CAN.-X by wire system-Interfacing of sensors and actuators with ECU.

Evaluation Pattern:

Evaluation Components	Internal	External
Continuous Assessment (Lab)*	70	-
End Semester	-	30

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,

21AT683 MACHINE LEARNING WITH PYTHON LAB 0-0-3-1

Course Objectives:
1.Introducing the python language, its modules system and its recommended programming styles and idioms.

2.Demonstrating problem solving using Python language and Demonstrating principles in a well-written modular code.
3.Problem solving of the physical systems using Python programming.

Course Outcomes
CO1: Understand the given programming language constructs.
CO2: Develop simple programs with scripts and control statements.
CO3: Illustrate problems machine learning methods.
CO4: Apply data analytics using python scientific packages.

	PO1	**PO2**	**PO3**	**P04**	**PO5**	**PO6**
CO1	3	2	2	0	3	0
CO2	3	2	2	0	3	0
CO3	3	2	2	0	3	0
CO4	3	2	2	0	3	0

Skills acquired: Problem solving of the physical systems/mathematical models using Python programming

Introduction to Python: motivation for learning Python in various engineering applications. The concept of data types: variables, assignments; numerical types; arithmetic operators and expressions; understanding error messages; Conditions, boolean logic, logical operators.

Control statements: if-else, loops (for, while); Continue; pass; break. Reading/writing text and numbers from/to a file; creating and reading a formatted file. Lists, tuples, Set and dictionaries: basic list operators, replacing, inserting, removing an element; searching
and sorting lists; adding and removing keys, accessing and replacing values.

Python packages for scientific computing: Numpy, SciPy, Pandas, Scikit-learn. Introduction to machine learning; Data analysis with python; Supervised Machine Learning; Statistics, Hypothesis Testing, Distributions; Time Series: Trends, Seasonality, Cyclic, Differencing. Linear regression, logistic regression, decision tree, random forest algorithm; data visualization.

Machine learning methods for predictive maintenance, condition monitoring, autonomous vehicles: Multivariate time series prediction; Support vector machines; Recurrent neural networks: convolution neural networks. An introduction on few python machine learning packages: Tensor flow; Keras and PyTorch.

TEXT BOOKS/REFERENCES:

1. Guttag, John. *Introduction to Computation and Programming Using Python: With Application to Understanding Data Second Edition*. MIT Press, 2016. ISBN: 9780262529624.

2. William McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython, Second edition (27 October 2017), Shroff/O'Reilly, ISBN-10: 9789352136414, ISBN-13: 978-9352136414
3. Hans Fangohr, Faculty of Engineering and the Environment, University of Southampton, *Introduction to Python forComputational Science and Engineering (A beginner's guide),* September 7, 2015. Online version availableat:*https://www.southampton.ac.uk/~fangohr/training/python/pdfs/Python-for-Computational-Science-and-Engineering.pdf*

Evaluation Pattern:

Evaluation Components	Internal	External
Continuous Assessment (Lab)*	70	-
End Semester	-	30

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,

21RM602 RESEARCH METHODOLOGY 2- 0- 0- 2

Course Objectives

1. To develop an understanding of the basic framework of research process

2. To identify various sources of information for literature review and data collection
3. To develop an understanding of the ethical dimensions of conducting applied research

Course Outcomes:

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**	**P04**	**PO5**	**PO6**
CO1	1	1	2	0	0	0
CO2	1	1	3	0	0	0
CO3	1	1	2	0	0	0
CO4	1	0	3	0	0	0
CO5	1	1	2	0	0	0
CO6	1	1	2	0	0	0

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

Evaluation Pattern:

Evaluation Components	Internal	External
Continuous Assessment	70	-
End Semester	-	30

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,

21AT612 VEHICLE DYNAMICS AND SIMULATION 3- 0- 3- 4

Course objectives:

1. To make the student understand the vehicle dynamics parameters
2. To make the student 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:

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: Simulation of various driving conditions and experimental validation

	PO1	PO2	PO3	P04	PO5	PO6
CO1	3	2	1			
CO2	1	2			3	
CO3	2		1		3	
CO4	2	1				3

Skills Acquired: analyze the vehicle response for various driving conditions and formulate the fundamental of vehicle dynamics. Simulation of various driving conditions and experimental validation

Introduction - Load distribution – calculation of CG of a vehicle – Effect of CG on vehicle performance.- Basic equation of Acceleration, Brake performance. Fundamental concepts in Mathematical Modelling –Lumped – Element Modeling-Mechanical systems Translational. Hydraulic systems. RLC Electrical Systems.

Understanding the Governing equations for free and forced responses – transient response specifications – Feedback systems- Systems with feedback – block diagrams – properties of feedback systems – relative stability-phase and gain margins.MATLAB based problems and solutions.(Matlab)

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.(Real test on road) (Simulation in IPG Carmaker)

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.(Real test on road)(Simulation in IPG Carmaker) .Modeling an Anti-Lock Braking System. (Matlab)

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.(Real test on road)(Simulation in IPG Carmaker). Magic Formula based tire modelling.(Matlab)

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 (Simulation in IPG Carmaker)

TEXT BOOKS/REFERENCES:

1. Thomas D.Gillespie, "*Fundamentals of Vehicle Dynamics*", SAE International Publication, 2005.
2. Popp, Karl, Schiehlen and Werner, "*Ground Vehicle Dynamics*", Springer Publication, 2010.
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, 2001.
5. Philip D Cha, James J Rosenberg and Clive L Dym, '*Fundamentals of Modeling and Analyzing EngineeringSystems",* Cambridge University, 2000.
6. Woods, Robert L., and Lawrence Kent L, "*Modeling and Simulation of Dynamic Systems*", Prentice Hall,1997.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	10	-
Periodical 2	10	-
Continuous Assessment (Theory)*	15	-
Continuous Assessment (Lab)*	30	-
End Semester	-	35

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT613 EMISSIONS, CONTROL AND FUEL CELLS 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 Outcome:

CO1: Recognize and identify selected modern emission systems to reduce emissions
CO2: Select alternate fuels for controlling engine emissions
CO3. Analyse the performance of the Fuel cells
CO4. Assess the performance requirements and decide on the control strategies

	PO1	PO2	PO3	P04	PO5	PO6
CO1	2			3		2
CO2		2		3		2
CO3	2	3		2	2	
CO4	2	3	2	2		2

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

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, Refueling, non regulated emissions-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

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 - Indian drive cycle- European test cycle-Emission Standards-Euro VI. Combustion Diagnostic Emission Control for Euro VI and future norms - Emission Standards for Inspection and Maintenance Programs - Remote Sensing of Vehicle Emissions: Operating Principles, Capabilities, and Limitations. Future trends- Alternate fuels-Fuel Options for Controlling Emissions -Alcohols and ethers-Bio-fuels, Synthetic fuels

Fuel Cell- 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- Energy conversion efficiency of fuel cells – Irreversible losses – Modelling approach – loss mechanism - Degradation mechanism and their life time- Design of Fuel cells for automotive applications

TEXT BOOKS/REFERENCES:

1. Colin Ferguson R., "*Internal Combustion Engines*", John Wiley and Sons, 2015.
2. Heywood J B, "*Internal Combustion Engine Fundamentals*", McGraw Hill International, 2017
3. Viktor Hacker, Shigenori Mitsushim,"Fuel cells and Hydrogen From Fundamentals to Applied Research"x Elsevier 2018
4. AsifFaiz, Christopher and S.Weaver, "*Air Pollution from Motor Vehicles: Standards and Technologies for Controlling Emissions*" World Bank Publication, 2000.
5. Corbo.P, Hydrogen Fuel Cells for Road Transportation, Springer London Ltd,.Springer 2016. ISBN: 9780857291356

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT614 **NVH AND REFINEMENT** **3- 0- 0-3**

Course Objectives:

1. Learn measurement and analysis techniques of vehicle noise and vibration
2. Expertise in the application of NVH refinement in vehicles and their systems
3. Understanding of advanced techniques for reduction of NVH

Course Outcomes:

CO1: Analyse vibrations of SDOF, MDOF and Continuous systems, vibration measurement and analysis
CO2: Measure vibration and noise signals and evaluate them applying signal processing and analysis 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: Apply advanced Techniques – NVH simulation, Statistical Energy Analysis, Acoustic Holography, beam forming, etc.,

	PO1	PO2	PO3	PO4	PO5	PO6
CO01	3	2	2	0	3	0
CO02	3	2	2	0	3	0
CO03	3	3	2	0	3	0
CO04	3	3	2	0	3	0
CO05	3	3	2	0	3	0

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

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.

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

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

TEXT BOOKS/REFERENCES:

1. Xu Wang, "*Vehicle Noise and Vibration Refinement*", CRC Press Publication, 2010.
2. J.M. KrodkiewskI, "*Mechanical Vibration*" Univ of Melbourne, 2008
3. Kihong Shin and Joseph K. Hammond "*Fundamentals of Signal Processing for Sound and Vibration Engineers*", Johe Wiley, 2008.
4. S.S.Rao, " Mechanical Vibrations", Prentice- Hall, 2011

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT615 ELECTRIC AND HYBRID VEHICLES 3–0–0–3

Course Objectives:

1. To familiarize various types of hybrid drive-train topologies

2. To introduce mathematical models to describe vehicle performance
3. To categorize Electric Propulsion unit and the Energy storage system
4. To understand the case studies of designing the Hybrid Electric Vehicle (HEV) and Battery Electric Vehicle (BEV)

Course Outcomes:

CO1: Compare and contrast different types of hybrid drive-train topologies
CO2: Solving mathematical models to describe vehicle performance
CO3: Categorizing Electric Propulsion unit and the Energy storage system
CO4: Understand the case studies of designing the Hybrid Electric Vehicle (HEV) and Battery Electric Vehicle (BEV)

	PO1	PO2	PO3	P04	PO5	PO6
CO1	3	3	3	2	1	1
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	3
CO4	3	3	2	2	1	1

Skills Acquired: Solving mathematical models to choose engines, electric propulsion systems and energy storage systems.

Electric Drive-trains and Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, Architecture – Basic architecture of hybrid drive train, power flow control in hybrid drive-train topologies, torque coupling and analysis of parallel drive train, architecture of electric drive-train, fuel efficiency analysis.

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine, Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology.

Energy Management Strategies: 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 Edition 2011.
2. MehrdadEhsani, YimiGao, Sebastian Longo, KambizEbrahimi, "*Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design"*, CRC Press, Third edition(Check) 2018
3. James Larminie, John Lowry, "*Electric Vehicle Technology*" Wiley, second ediion.2012.
4. "Electricand Hybrid Vehicles", Routledge, Second Edition 2020

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT684 NVH LAB 0-0-3-1

Course Objectives:

1. To introduce the students to perform a modal study of a part

2. To introduce the students to perform a vibration study of an assembly
3. To introduce environmental sound measurement using sound level meter
4. To use the sound as the parameter for identifying the noise source of an automobile

Course Outcomes:

CO1: Conduct the Modal testing and analyze the signals using FFT
CO2: Identify the noise source and measure the vehicle noises like passby noise, stationary noise
CO3: Analyze the sound quality

	PO1	PO2	PO3	P04	PO5	PO6
CO1	2		2	3	2	
CO2	2		2	3	2	
CO3	2	3	3	3	3	

Skills Acquired: Conduct the Modal testing and analyze the signals using FFT and Analyze the sound quality

Sound Power evaluation using SPL measurements- ISO 3744, Engine SPL measurement as per SAE, Modal Testing and analysis, Signal Analysis using FFT, Demonstration of inverse square law, Demonstration of the effect of sound absorbing and insulating materials, Noise source identification by masking method, Motor vehicle passby noise- IS 3028/ISO 362, Motor vehicle Stationary noise (tail pipe noise)- ISO 10399, Sound Quality analysis - Jury Rating, Metrics and its correlation- Vibration measurement and Modal analysis

Evaluation Pattern:

Evaluation Components	Internal	External
Continuous Assessment (Lab)*	70	-
End Semester	-	30

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,

21AT701 COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER 2-0-3-3

Course Objectives:

1.To study the basic governing equations and understand the basic properties of CFD.
2. To utilize 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:

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: Applythe various discretization methods, solution procedures and turbulence modeling to solve flow and heat transfer problems.
CO4: Apply the knowledge to interpret, solve and analyze engineering flow problems.

	PO1	PO2	PO3	P04	PO5	PO6
CO1	3	3	2	1	3	1
CO2	3	3	2	1	3	1
CO3	3	3	2	1	3	1
CO4	3	3	2	1	3	1

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

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.

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.

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 OpenFoam/PyCFD and other commercial softwares.

Lab Exercise:
1. Convective flow through a pipe.
2. Flow around a cylinder (unsteady).
3.Driven cavity flow using OpenFoam
4. A sector modelling and analysis of internal combustion engines.
5.Battery thermal modeling for Li-ion battery packs.

TEXT BOOKS/REFERENCES:

1. Versteeg, H.K., and Malalasekara, W, "*An Introduction to Computational Fluid Dynamics",* The Finite Volume Method, 2007
2. Moukalled, F., Mangani, L., and Darwish, M. "*The finite volume method in computational fluid dynamics. An Advanced Introduction with OpenFOAM and Matlab*", 2016.
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

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	10	-
Periodical 2	10	-
Continuous Assessment (Theory)*	10	-
Continuous Assessment (Lab)*	40	-
End Semester	-	30

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,

21AT702 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:

CO1 :Classify and 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 analyze, static and dynamic, linear and non-linear multi-physics problems using a finite element package

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	1	1	3	1
CO2	3	3	2	2	3	2
CO3	3	3	2	3	3	3
CO4	3	3	2	1	3	1
CO5	3	3	3	3	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.

Syllabus:

Fundamentals of 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, 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.

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:

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. **(Tool: Abaqus)**

TEXT BOOKS/REFERENCES:

1. Thomas J. R. Hughes, "*The Finite Element Method – Linear Static and Dynamic Finite Element Analysis*", Dover Publications Inc, 2003.
2. Rao S. S., "*The Finite Element Method in Engineering*", Fourth Edition, Elsevier, 2007.
3. Daryl L. Logan, "*A First Course in the Finite Element Method*", Fourth Edition, Cengage Learning, 2007.
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. Zienkiewicz O. C., "*The Finite Element Method for Solid and Structural Mechanics*", Sixth Edition, Butterworth-Heinemann, 2005.
7. Jacob Fish and Ted Belytschko, "*A First Course in Finite Elements*", Wiley Inter Science, 2007.
8. DS Simulia, "*Abaqus Documentation*", Abaqus version 6.16.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	10	-
Periodical 2	10	-
Continuous Assessment (Theory)*	10	-
Continuous Assessment (Lab)*	40	-
End Semester	-	30

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,

21AT703 TESTING AND VALIDATION 3-0-0-3

Course Objectives:

1. Understand the need and objectives of testing, and the required tests on vehicle, power plant and components along with the test codes, CMVR/AIS requirements
2. Understand various instrumentation, data acquisition and analysis systems used in testing

3. Understanding and application of principles of DOE, Virtual Product development and Testing

Couse Outcomes:

CO1: Analyse the need, objectives and types of testing
CO2; Apply Measurement systems, Instrumentation, data acquisition and analysis systems for testing
CO3: Apply various methods of testing to vehicles, prime movers, drivelines, components, and materials including emissions, EMI/EMC, fatigue, crash, etc.
CO4: Apply design of Experiments (DOE), Taguchi's methods for testing
CO5: Apply various national and International standards for testing

	PO1	PO2	PO3	PO4	PO5	PO6
CO01	3	0	0	0	0	0
CO02	3	2	2	0	3	0
CO03	3	3	2	0	3	0
CO04	3	3	2	0	3	0
CO05	3	0	2	0	0	0

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

Need for testing and validation – Vehicle Classification vehicle development process - Types of testing –Objectives of testing- Measurement of Real world usage patterns and their analysis – design of test specifications-Engine testing – Definitions and calculations – Instrumentation-Transducers and Data Acquisition Systems and Analysis – Services Vehicle tests –Tests on components and systems, brake testing

EMI/EMC/EMS testing and regulations-Safety and crash testing– Regulatory and NCAP tests – Injury criteria - Materials and material testing-Servo-hydraulics and fatigue testing-Testing of EHVs

CMVR – Indian and Automotive Industry standards – International standards and WP 29 Virtual product development and computer aided engineering – virtual testing - Road to lab to desktop Design of experiments – Basic concepts - application of statistics – Analysis of variance - factorial testing –- Taguchi methods

TEXT BOOKS/REFERENCES:

1. Martyr and Plint, "*Engine Testing – Theory and Practice*", Butterworth Heinemann, 2007.
2. Douglas Montgomery, "*Design and Analysis of Experiments*", John Wiley, 2008.
3. Jiju Antony, "*Design of Experiments*" Butterworth & Heinemann, 2003.

4. Hinkleman and Kempthone, "*Design and Analysis of Experiments – Advanced Experimental Design*", John Wiley& Sons, 2005
5. CMVR, *TAPS document, Indian Standards, AISs, ISOs, etc*

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT704 SPECIAL TOPICS IN ADVANCED ENGINEERING APPLICATION 3-0-0-3

Course Objectives:

1. To acquire technical knowledge in recent developments in automotive sector
2. To improve skills on technical presentation in the relevant topics
3. To develop knowledge on materials, technologies, processes, developments, recent trends etc., in Automotive domine

Couse Outcomes:

CO1: Interpret the recent trends in electric vehicles and respective systems
CO2: Acquire the recent advancements in auto infotronics, OBD, Vehicle Intelligence.
CO3: Demonstrate the concept of lightweight materials in automotive applications.

	PO1	PO2	PO3	P04	PO5	PO6
CO1	3	1	2			
CO2	2					
CO3	2		1			

Skills Acquired: Learned recent advancements in auto infotronics, OBD, Vehicle Intelligence and Electric vehicle.

- Light weighting for electric vehicles.
- Green engine technology.
- Battery management systems.
- Hybrid Technology
- Tribology of Automotive Components
- Additive Manufacturing for Automotive Applications.
- Electrocoating for automotive applications.
- Connected cars-Requirements &Technical feasibility.
- Advancement in on board diagnostics.
- Autotronics and Vehicle Intelligence.
- Visco-Elastic Materials and Vibration Control
- Flow-Induced Noise and Vibration Sources in Automotive systems.
- Surface Coatings for Automotive Applications.
- Autonomous vehicle
- Electric vehicles
- Advanced Welding Technology for Automotive applications

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-

End Semester	-	50

Note: Evaluation for this course is based on Review documents, Reports, and Presentation

21AT705 OFF-HIGHWAY MOBILITY 3- 0- 0- 3

Course Objectives:

- To understand the types of off road vehicles
- To evaluate various terrain behaviour and to predict the performance of off road vehicles
- To design the mechanical and hydraulic dredgers

Couse Outcomes:

CO1: Illustrate the off-road vehicle morphology and understand the human safety in handling
CO2: Apply terramechanics to evaluate terrain behaviour
CO3: Evaluate the performance of off-road vehicles
CO4: Design of Dredgers, Cranes and Intelligent systems

	PO1	PO2	PO3	P04	PO5	PO6
CO1		3	2		2	1
CO2	1	3	2		2	
CO3	2	3	2	2	2	2
CO4	1	3	2		2	

Skills Acquired: Evaluate the Off-Road vehicle performance and design the Dredgers, Crane, Tractor

Study of morphology, operational characteristics, and design considerations of off-road vehicles used in the agriculture, infrastructure and construction. Traction and Tractor Performance, Tractor, harvester, windrowers: engine performance and design, vehicle testing, turbo chargers and intercoolers, drive trains, chassis mechanics, hydraulic systems including PTO. Drawbar Performance.

Introduction to Terramechanics and Off-road vehicle Engineering. Role, measurement and modelling of Terrain Behaviour. Methods for Evaluating Tracked and Wheeled Vehicle Performance, empirical methods and parametric analysis.

Design of Mechanical and Hydraulic dredges – backhoe, tracked excavator, pick and carry crane, soil compactor. Mechatronics for Off-road Vehicles, Electrohydraulic Steering Control, Design of Intelligent systems.

Tractor Test procedure –Nebraska Test. Emission norms and legislative requirement for off highway vehicles. OECD Standard codes.

TEXT BOOKS/REFERENCES:

1. Carroll E. Goering, "*Off-Road Vehicle Engineering Principles*", American Society of Agricultural Engineers, 2003.
2. J.Y. Wong, "*Terramechanics and Off-Road Vehicle Engineering*", Second Edition, Butterworth Heinemann, 2009.
3. Frank M. Zoz and Prbert D. Grisso*, "Traction and Tractor Performance*",American Society of Agricultural Engineers, 2003.
4. Francisco Rovira Mas and Qin Zhang and Alan C. Hansen, "*Mechatronics and Intelligent systems for Off-road Vehicles.*", Springer, 2010.
5. GianpieroMastinu, Manfred Ploechl "*Road and Off-Road Vehicle System Dynamics Handbook''* CRC Press, 2014.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT706 VEHICLE BODY ENGINEERING 3-0-0-3

Course Objectives:

1. Understanding of the types, construction, requirements including mandatory, and manufacture of car, bus and truck bodies
2. Understanding of body mechanisms, trim and materials
3. Application of structural analysis to the car bodies

Course Outcomes:

CO1: Categorize the types of Vehicle Bodies
CO2: Evaluate the different Construction Methodologies of the Vehicle Bodies
CO3: Apply the Regulations for vehicle body construction
CO4: Select the Body Materials and Trims
CO5: Structural analysis of the vehicle body structure

	PO1	PO2	PO3	PO4	PO5	PO6
CO01	3	0	0	0	0	0
CO02	3	0	0	0	0	0
CO03	3	0	0	0	0	0
CO04	3	0	0	0	0	0
CO05	3	3	2	0	3	0

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

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.

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

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.

.

TEXT BOOKS/REFERENCES:

1. Lorenzo Morello, Lorenzo Rosti Rossini, Giuseppe Pia, Andrea Tonoli, "*The Automotive Body, Vol 1 Components Design*, Vol2: 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. JanuszPawłowski, "*Vehicle Body Engineering,* 1969, Business Books
4. AIS 052: Code pf Practice for Bus Body Design and Approval, ARAI, Pune
5. AIS 093: Code pf Practice for Construction and Approval of Truck Cab and truck Bodies, ARAI, Pune.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT707 AUTOMOTIVE SAFETY SYSTEMS 3- 0- 0- 3

Course Objectives:

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

Course Outcomes:

CO1: Analyze 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

	PO1	PO2	PO3	P04	PO5	PO6
CO1	2	1	0	0	2	3
CO2	2	1	0	0	2	3
CO3	2	1	0	0	2	3
CO4	2	1	0	0	2	3

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

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.

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.

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).

TEXT BOOKS/REFERENCES:

1. Johnson W and Mamalis A.G., "Crashworthiness of Vehicles", Mechanical Engineering Publications, 2002.
2. Matthew Huang, "Vehicle Crash Mechanics", CRC Press,2002

3.Olson L. P., “Forensic Aspects of Driver Perception and Response”, Lawyers and Judges, 3rd edition 2009.
4. Daniel J Helt, “Recent Development in Automotive Safety Technology”, SAE International Publication, 2004.
5. Robert Bosch, “Safety Comfort and Convenience Systems”, Wiley, 2007.
6. Richard Bishop, “Intelligent Vehicle Technology and Trends”, Artech House, 2005.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT708 AUTOMOTIVE INFOTRONICS 2-0-3-3

Course Objectives:

1. To understand the working of various peripherals of automotive controller S12XE
2. To make use of Code Warrior IDE for programming S12XE for various automotive applications
3. To introduce basics of modeling, simulation and Hardware in Loop testing of various automotive subsystems
4. To introduce to OSEK/VDX Environment, AUTOSAR layered software architecture

Couse Outcomes:

CO1: Analyze working of various peripherals of automotive controller S12XE
CO2: Make use of Code Warrior IDE for programming S12XE for various automotive applications
CO3: Apply basics of modeling, simulation and Hardware in Loop testing of various automotive subsystems
CO4: Introduced to OSEK/VDX Environment, AUTOSAR layered software architecture

	PO1	PO2	PO3	P04	PO5	PO6
CO1	3	2	2	-	3	2
CO2	3	2	2	1	3	3
CO3	3	3	3	2	3	3
CO4	2	2	2	-	1	-

Skills Acquired: Modeling, simulation and Hardware in Loop testing of various automotive subsystems.Code Warrior IDE for programming S12XE for various automotive applications

Introduction to Automotive Controllers – S12XE: 18-Bit Automotive Microcontroller, Port Integration, Memory mapping control, memory protection, External bus interface, interrupts, clock and reset, ADC, Scalable Controller Area Network, periodic interrupt timer, PWM, serial peripheral interfaces, Timer module

Body Controller Application Example, Programming using code warrior IDE. Introduction to longitudinal and lateral vehicle control, Modeling and simulation study of ABS, Adaptive cruise control, Electronic stability control, Active suspension control

Basics of Rapid Control Prototyping and Hardware-in-the-Loop simulation. X-by-wire technology: Brake-by-wire, Steer-by-wire and Throttle-by-wire, Sensors, Actuators and Controllers, Fault-tolerant electronic sub-systems. Introduction to OSEK/VDX Environment, AUTOSAR layered software architecture.

Lab Components:

1. Modeling and Simulation Experiments using MATLAB & Simulink – Controller Design for ABS, Steer-by-wire system and Throttle-by-wire system
2. Rapid Control Prototyping and Hardware-in-the-Loop Simulation of Controllers for Steer-by-wire system and Throttle-by-wire system Using MATLAb & Simulink Embedded Coder , on Texas Instruments - C2000 Development Board and Speed Goat Real-time Target Machines

TEXT BOOKS/REFERENCES:

1. MC9S12XEP100 Reference Manual Covers MC9S12XE Family.
2. Rajesh Rajamani, "*Vehicle Dynamics and Control*", Springer, 2005.
3. UweKiencke and Lars Nielsen, "*Automotive Control Systems: For Engine, Driveline, and Vehicle*", Second Edition, Springer 2005.
4. Joseph Lemieux, "*Programming in the OSEK/VDX Environment*", CMP Books, 2001
5. OSEK/VDX Environment, AUTOSAR layered software architecture, 2009.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	10	-
Periodical 2	10	-
Continuous Assessment (Theory)*	10	-
Continuous Assessment (Lab)*	40	-
End Semester	-	30

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,

21AT709 PROJECT MANAGEMENT 3- 0- 0- 3

Course Objectives:

1. To help in understanding the differences between past and present methods of managing projects.

2. To help in learning the theory of project organisations, and their applications in modern projects firms.
3. To help in improving the skills of using the project execution tools and techniques.
4. To recognize the various kinds of project network problems and identify the appropriate quantitative analytical tools to solve those problems.
5. To analyse and evaluate the operational issues of the project organisations.

Course Outcomes:

CO1. Explore the different phases of project management
CO2. Apply the tools and techniques to assess a project
CO3. Understand and execute different project management processes taking place throughout the project life cycle
CO4. Support projects in planning, organising and managing resources through software

	PO1	PO2	PO3	P04	PO5	PO6
CO1	2	2	1			
CO2	2			1		
CO3	1	2				
CO4	3	2	2	1		

Skills acquired: Compare and analyse the project performance; Critical and integrative thinking

Introduction to Project Management; History of Project Management; Project Life-Cycle; Feasibility Study; Project Selection; Project Estimating; Planning and Control Cycle; Scope Management

Work Breakdown Structure; Critical Path Method; Schedule Bar chart; Procurement Schedule; Resource Planning; Project Accounts; Project Control; Earned Value;

Quality Management; Project Risk Management; Project Communication; Project Organisation Structures; Project Teams; Project Leadership;

Project Management Computing; Microsoft Project for Scheduling; Microsoft Project for Resource Planning and Levelling

TEXT BOOKS/REFERENCES:

1. Burke, Rory. (2016). *Project management: planning and control techniques*. Wiley, India
https://www.microsoft.com/en-in/microsoft-365/project/project-management-software
2. Mubarak, S. A. (2015). *Construction project scheduling and control*. John Wiley & Sons.
3. Larson, E. W., & Gray, C. F. (2011). *Project management: The managerial process*.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT710 AUTOMOTIVE HVAC, CABIN COMFORT AND ERGONOMICS 3- 0- 0- 3

Course Objectives:

1. To utilize safety procedures to diagnose and repair, and elaborate the operation of the basic refrigeration cycle
2. To describe the operation of air conditioning and heating controls
3. To perform test and evaluate energy efficiency of HVAC system.
4. To diagnose automotive AC and cabin comfort problems

Couse Outcomes:

CO1: Apply the operating principle of automotive HVAC Systems and troubleshooting
CO2: Analyze the operating cycles and Design the HVAC system
CO3: Evaluate the cabin comfort and analyze the energy efficiency
CO4: Examine the passenger ergonomics and understand the Psychological factors

	PO1	PO2	PO3	P04	PO5	PO6
CO1	2	2	1	-	-	-
CO2	2	2	1	-	-	-
CO3	2	2	1	-	-	1
CO4	2	2	1	-	-	1

Skills Acquired: Analyze the operating cycles, Design the HVAC system and evaluate the cabin comfort and analyze its energy efficiency

History and Development- Health and Safety - Tools and Measuring Systems – Comfort - Pressure and Temperature - Refrigerants and Lubricants - Special Service Tools - Moisture and Moisture Removal - The Refrigeration System - Compressors and Clutches. Compressor Service - System Components and Metering Devices - Electricity and Electronics Review - Electrical Circuits - Control Devices -Case/Duct Systems -Engine Cooling and Comfort Heating - Troubleshooting and Repair.

Applications of HVAC fundamentals to analysis and design of automotive air conditioning systems. Psychometrics, passenger thermal comfort, refrigeration cycles and system design, central and Unitary systems, heating system design, air flow circuits, Air cleaning, ventilation, air space diffusion, compact heat exchanger design, controls and instrumentation. Cabin comfort- In-car air conditioning - overall energy efficiency - air management.
Design of HVAC System -Modeling flow system using computational fluid dynamics, numerical approaches, turbulence models, design considerations specific to HVAC.

Vehicle Ergonomics : Introduction to human body - Anthropometrics and its application to vehicle ergonomics and cockpit design- Driver comfort – seating, visibility, man-machine system-consideration of women drivers-Psychological factors – stress, attention- Passenger comfort-Passenger safety - Ingress and egress, spaciousness, ventilation, temperature control, dust and fume prevention and vibration - Interior features and conveniences.

TEXT BOOKS/REFERENCES:

1. Boyce Dwiggins, "*Automotive Air Conditioning*", Delmar Cengage Learning, 2001.

2. Steven Daly, "*Automotive Air Conditioning and Climate Control Systems*", Butterworth Heinemann, 2006.
3. John Haynes, "*Automotive Heating and Air Conditioning Systems Manual*", Haynes Publications, 2000.
4. ASHRAE Handbook, SI Edition, 2011
5. B.Peacock, WaldemarKarwowski; "*Automobile ergonomics*." Publisher: CRC; 1 edition, 1993

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT711 MEMS (MICRO-ELECTRO MECHANICAL SYSTEMS) FOR AUTOMOTIVE APPLICATIONS **3- 0- 0- 3**

Course Objectives:

1: To acquire knowledge on various techniques involved in MEMS device fabrication
2: To familiarize with transduction mechanisms and modeling in different energy domains
3: To apply MEMS skills to integrate automotive sensors and actuators
4: To use soft tools to design and analyze MEMS

Couse Outcomes:

CO1: Introduce to process and various techniques involved in MEMS device fabrication
CO2: Understand the transduction mechanisms and modeling in different energy domains
CO3: Learn the applications of MEMS in automotive sensors and actuators
CO4: Design and analyze MEMS based sensors/actuators using CAD

	PO1	PO2	PO3	P04	PO5	PO6
CO1	1					
CO2	2	1	1			
CO3	2		1			
CO4		3		1	1	2

Skills Acquired: Analysemicro-machined sensors/actuators and design MEMS using CAD

Micro electro mechanical systems (MEMS), devices, and technologies.Micro-machining and microfabrication techniques, including planar thin-film processing, silicon etching, wafer bonding, photolithography, deposition, and etching.

Transduction mechanisms and modeling in different energy domains.Electrostatic Sensing and Actuation, Thermal Sensing and Actuation, Piezoresistive Sensors, Piezoelectric Sensing and Actuation, Magnetic Actuation-demo on electro mechanical sensor.

Computer-aided design for MEMS layout, fabrication, and analysis. MEMS for passenger safety in automotive vehicles, MEMS sensors for automotive vehicle stability control applications, MEMS for automotive tire pressure monitoring systems, MEMS pressure and flow sensors for automotive engine management, RF MEMS for automotive radar sensors, MEMS for passenger comfort in vehicles

TEXT BOOKS/REFERENCES:

1. Michael Kraft and Neil White, MEMS for Automotive and Aerospace Applications, 1st Edition, Woodhead Publishing, 2013
2. Chang Liu, Foundations of MEMS, 2nd Edition, Pearson Education, 2011
3. Tai-Ran Hsu, MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering, 2nd Edition, John Wiley & Sons, 2008
4. Jiri Marek, Hans-Peter Trah, Yasutoshi Suzuki, IwaoYokomori, Sensors for Automotive Applications, WILEY-VCH, 2003
5. Jan Korvink and Oliver Paul, MEMS: A Practical Guide to Design, Analysis and Applications, William Andrew Publishing, 2006.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,

21AT712 AUTOMOTIVE TRIBOLOGY 3- 0- 0- 3

Course objectives:

1: To introduce principles of tribology and dynamics
2: To understand surface phenomenon in thin-film tribology
3: To understand the tribological considerations in IC engines
4: To understand tribological aspects in drivetrains

Course Outcomes:

CO1. Evaluate the tribological requirements of engine and transmission systems
CO2. Analyse thin-film tribology and its effect on engine and transmissions.
CO3. Apply the knowledge for measurement of lubricating film thickness, wear etc.,
CO4. Address tribological requirements of drivetrain systems

	PO1	PO2	PO3	P04	PO5	PO6
CO1		2			2	
CO2		3		2		2
CO3	2	3		2	1	
CO4	2	2	1		2	2

Skills Acquired: Evaluate tribological requirements of engines – piston, piston-ring, cylinder liner, engine bearings and analyse the wear and friction behaviour in various automotive transmission systems and select proper lubricants

Mechanisms and laws of friction and wear,surface tension, contact angle, Vander Waals forces, Fluid film lubrication, Lubricant properties, Reynolds equation, N-S equation, free surface behavior of lubricant films, Elastrohydrodynamic lubrication

Tribological considerations in design of engines, piston ring conjunction cams, reciprocating components, Engine tribology – piston systems, measurement techniques for piston-ring tribology, ultrasonic approach, Oil films, surface texturing, LST

Valve train systems – Tribology issues in cam-tappet contacts, Engine bearings, Determination of bearing loads, tribological conditions, tribological issues in big end bearings, Lubricant rheology Drive train systems – Clutch, Judder and shuffle, tribology of transmissions, differentials, clutch assembly, steering gear, brakes and tires, propeller shafts and CV joints.Tribological considerations in the design and development of slip control devices, Rattle and clatter noise in powertrains- Automotive transmission lubricants.-Tribology of electric vehicles. **Lab content**: Wear characteristics of component materials used in engines. Friction study of reciprocating and rotating components

TEXT BOOKS/REFERENCES:

1. Homer Rahnejat, "Tribology and Dynamics of Engine and Powertrain", Woodhead Publishing, 2011.
2. Halling J., "*Principles of Tribology*", McMillan Press Ltd, 2000.
3. Neale M. J. "*Tribology Hand Book*", Butterworth Heinemann, 2002.
4. Fuller D. D., "*Theory and Practice of Lubrication for Engineers*", John Wiley, 2004.
5. Stachowiak.G and Batchelor A.W., "Engineering Tribology", 4th edition, Butterworth Heinemann, 2013.

Evaluation Pattern:

Evaluation Components	Internal	External
Periodical 1	15	-
Periodical 2	15	-
Continuous Assessment *	20	-
End Semester	-	50

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,