VIT®

Vellore Institute of Technology

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

SCHOOL OF MECHANICAL ENGINEERING

M.Tech Automotive Engineering

Curriculum & Syllabi

(*2023-2024 batch onwards*)

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

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

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

VISION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To be a leader in imparting world class education in Mechanical Engineering, with a vision to nurture scientists and technocrats of the highest caliber engaged in global sustainable development.

MISSION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To create and maintain an environment fostering excellence in instruction & learning, Research and Innovation in Mechanical Engineering and Allied Disciplines.
- To equip students with the required knowledge and skills to engage seamlessly in higher educational and employment sectors ensuring that societal demands are met.

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M. Tech Automotive Engineering

PROGRAMME OUTCOMES (POs)

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

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

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

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

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

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

PO_07: Having a clear understanding of professional and ethical responsibility.

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

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M. Tech Automotive Engineering

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Automotive Engineering) programme, graduates will be able to

- **PSO_1:** Compute, Design, Simulate & analyse various Automotive engineering systems taken into account the social, economic and environmental implications for the current and future mobility.
- **PSO_2:** Practice a multidisciplinary approach to solve real-world automotive problems.
- **PSO_3:** Independently carry out research / investigation to solve practical problems and write / present a substantial technical report/document

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M. Tech Automotive Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

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

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

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

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

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

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

Agenda Item 67/11

To consider and approve the revised programme credit structure, curriculum and course contents of Master of Technology in Automotive Engineering

ANNEXURE – 15

Master of Technology in Automotive Engineering

School of Mechanical Engineering

Programme Credit Structure	**Credits**
Discipline Core Courses	24
Skill Enhancement Courses	05
Discipline Elective Courses	12
Open Elective Courses	03
Project/ Internship	26
Total Graded Credit Requirement	70

Discipline Core Courses **24**

		L	T	P	C
MMAT502L	Advanced Mathematical Methods	3	0	0	3
MAUE501L	Automotive Body and Chassis Systems	3	0	0	3
MAUE502L	Engine Combustion and Emission	3	0	0	3
MAUE502P	Engine Combustion and Emission Lab	0	0	2	1
MAUE503L	Automotive Electrical and Electronics	3	0	0	3
MAUE503P	Automotive Electrical and Electronics Lab	0	0	2	1
MAUE504L	Automotive Transmission System	3	0	0	3
MAUE505L	Vehicle Dynamics	3	0	0	3
MAUE505P	Vehicle Dynamics Lab	0	0	2	1
MAUE506L	Hybrid Electric Vehicles	3	0	0	3

Skill Enhancement Courses **05**

MENG501P	Technical Report Writing	0	0	4	2
MSTS501P	Qualitative Skills Practice	0	0	3	1.5
MSTS502P	Quantitative Skills Practice	0	0	3	1.5

Discipline Elective Courses **12**

MAUE601L	Engine Design and Development	3	0	0	3
MAUE602L	Battery and Fuel Cell	3	0	0	3
MAUE603L	Vehicle and Engine Testing	3	0	0	3
MAUE604L	Vehicle Maintenance and Diagnostics	3	0	0	3
MAUE605L	Vehicle Aerodynamics	3	0	0	3
MAUE606L	Vehicle Crashworthiness	3	0	0	3
MAUE607L	Design of Vehicle Drivelines	3	0	0	3
MAUE608L	Noise, Vibration and Harshness	3	0	0	3
MAUE608P	Noise, Vibration and Harshness Lab	0	0	2	1
MAUE609L	Computational Fluid Flow and Heat Transfer	3	0	0	3
MCDM504L	Finite Element Methods	3	0	0	3
MCDM504P	Finite Element Methods Lab	0	0	2	1
MAUE611L	Vehicle Safety and Lighting	3	0	0	3

Open Elective Courses **03**

Engineering Disciplines | Social Sciences

Project and Internship **26**

MAUE696J	Study Oriented Project	02
MAUE697J	Design Project	02
MAUE698J	Internship I/ Dissertation I	10
MAUE699J	Internship II/ Dissertation II	12

Course Code	Course Title	L	T	P	C
MAUE501L	Automotive Body and Chassis Systems	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To introduce vehicle chassis structure
2. To introduce automotive suspension systems
3. To broaden the importance of conventional and advanced braking systems
4. To introduce steering systems

Course Outcome

The student shall be able to:

1. Choose and suggest a suitable chassis layout, frame and body construction type for different cars & bus
2. Designing suitable chassis layout for commercial vehicles.
3. Determine and analyze various types of steering systems
4. Select and analyze a suitable suspension system for different types of vehicles
5. Suggest, Identify and Design suitable type of braking system for different types of vehicles

Module:1	Car Body	7 hours

Types: saloon, convertibles, limousine, estate car, racing and sports car. Visibility: regulations, driver's visibility, tests for visibility, methods of improving visibility, and space in cars. Safety: safety design, safety equipment for cars. Car body construction; design criteria, prototype making, initial tests, crash tests on full scale model, Dummies, and Instrumentation.

Module:2	Bus Body	5 hours

Types: minibus, 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, Regulations, Conventional and integral type construction.

Module:3	Commercial Vehicles	5 hours

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. Drivers cab design.

Module:4	Chassis	7 hours

Types of Chassis layout, with reference to Power Plant location and drive, various types of frames, Loads acting on vehicle frame, Constructional details and materials for frames, Testing of frames. Integral construction, Monocoque, Back bone.

Module:5	Steering System	6 hours

Front wheel geometry: castor, camber, king pin inclination, toe-in. conditions for true rolling motion of wheels during steering, steering geometry, Ackermann and Davis steering system, constructional details of steering linkages, different types of steering gear boxes, steering linkages and layouts, turning radius, wheel wobble, power assisted steering. Steer by wire

Module:6	Suspension System	6 hours

Need of suspension system, types of suspension, suspension springs, constructional details and characteristics of leaf, coil and torsion bar springs, independent suspension, rubber suspension, pneumatic suspension, shock absorbers. MR dampers, Bose suspension

Module:7	**Braking System**	**6 hours**
Classification of brakes, drum brakes and disc brakes, constructional details, theory of braking, concept of dual brake system, Anti-lock braking system, electronic brake force distribution, parking brake, vacuum assisted system, air brake system, retarded engine brakes, eddy retarders, Electronic stability control		
Module:8	**Contemporary Issues**	**3 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Automotive Mechanics, William Crouse and Donald Anglin, McGraw Hill Education; 10th edition (1 July 2017); McGraw Hill Education
Reference Books	
1.	Heinz Heisler, “Advanced Vehicle Technology”, (2011), Butterworth-Heinemann. ISBN – 0 7506 51318,
2	“Automotive Technology: A Systems Approach”, Cengage Learning; 7th edition (January 1, 2019)
3	John Fenton, “Vehicle Body layout and analysis” (1982), Mechanical Engg. Publication Ltd., London.
4	Newton Steeds and Garret, “Motor Vehicles” 13th Edition, Butterworth, London, 2005.
5	R.K.Rajput, “A Text–Book of Automobile Engineering”,(2018),Laxmi Publications Private Limited.
	Authors, book title, year of publication, edition number, press, place

Mode of Evaluation: CAT, Assignment, Quiz, FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE502L	Engine Combustion and Emission	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To broaden the understanding of engine and its working
2. To underline the importance of engine components
3. To introduce fuel supply, cooling and lubrication systems
4. To broaden the importance of air motion and combustion chamber design
5. To introduce new engine technology

Course Outcome

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

1. Understand the combustion phenomena of premixed and diffusion combustion systems
2. Determine fuel rating and ignition systems
3. Design suitable combustion chamber with enhanced air motion and better mixing
4. Adopt new emission control technologies
5. Validate the engine emission characteristics with BS norms
6. Calibration and measurement of emission analysers
7. Analysing the cylinder pressure data to determine various combustion parameters

Module:1	**Introduction to Engines**	**3 hours**
Construction and working, Engine operating Cycles–Ideal and Fuel Air Cycles, Engine Classifications		
Module:2	**SI Engine Combustion**	**8 hours**
Stages of Combustion, Phases of Ignition, Flame Propagation – Factors, Flame Structure, Burning Velocity, Cycle to Cycle Variations		
Module:3	**CI Engine Combustion**	**8 hours**
Stages of Combustion, Heat Release Rate analysis, Ignition Delay – Factors, Fuel spray structure, Spray Penetration, Spray angle, Droplet distribution and Evaporation		
Module:4	**Abnormal Combustion**	**4 hours**
Knocking and Detonation Concepts, Knock types, Surface Ignition, Fuel Ratings		
Module:5	**Oxides of Nitrogen Emission**	**6 hours**
Kinetics of NO formation, NO formation in SI Engines, NOx formation in CI Engines – Controlling Techniques –SCR		
Module:6	**Unburned Hydrocarbon and CO Emission**	**6 hours**
Carbon monoxide Formation, Flame Quenching and Oxidation, HC emissions in SI Engine, HC emissions Mechanism in Diesel Engines – Controlling Techniques – Catalytic Converters		
Module:7	**Particulate Emissions and Exhaust gas Treatment**	**8 hours**
SI Engine Particulates, Diesel Engine Particulates, Particulate Distribution, Soot Formation, Adsorption and Condensation Emission Testing Methods, Thermal reactors, Particulate Traps – DPF, DOF		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	John B Heywood, “Internal Combustion Engine Fundamentals”, (2018), McGraw Hill Education.

Reference Books

1.	V. Ganesan, “Internal Combustion Engine”, (2017), 4th Edition, McGraw Hill Education.
2.	Stephen R Turns, “An Introduction to Combustion: Concepts and Applications”, (2021), McGraw Hill Education, 4th Edition.
3.	James D Halderman, “Automotive Fuel and Emissions Control Systems”, (2015), Prentice Hall, 4th Edition
4.	Klingenberg H, “Automobile Exhaust Emission Testing”, (2012), Springer.

Mode of Evaluation**:** CAT, Written assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE502P	Engine Combustion and Emission Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To broaden the understanding of engine and its working
2. To underline the importance of engine components
3. To introduce fuel supply, cooling and lubrication systems
4. To broaden the importance of air motion and combustion chamber design
5. To introduce new engine technology

Course Outcome

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

1. Understand the combustion phenomena of premixed and diffusion combustion systems
2. Determine fuel rating and ignition systems
3. Design suitable combustion chamber with enhanced air motion and better mixing
4. Adopt new emission control technologies
5. Validate the engine emission characteristics with BS norms
6. Calibration and measurement of emission analysers
7. Analysing the cylinder pressure data to determine various combustion parameters

Indicative Experiments	
1.	Performance, heat balance and emission analysis of S.I Engine
2.	Performance, heat balance and emission analysis of C.I Engine
3.	Dismantling and assembling an automotive diesel engine
4.	Fuel property testing (Calorific value, Density and Viscosity)
5.	Fuel property testing (Flash, Fire point, Pour point, Cloud point)
6.	Cylinder pressure measurement and Combustion analysis
7.	NOx emission control through EGR and Injection retardation
8.	NOx emission control through Injection retardation
9.	Smoke emission control through biodiesel blended diesel
10.	NOx and HC emission control through ethanol blended gasoline
	Total Laboratory Hours **30 hours**

Text Book(s)

1. John B Heywood, “Internal Combustion Engine Fundamentals”, (2018), McGraw Hill Education.

Reference Books

1. V. Ganesan, “Internal Combustion Engine”, (2012), 4th Edition, McGraw Hill Education.
2. Stephen R Turns, “An Introduction to Combustion: Concepts and Applications”, (2021), McGraw Hill Education, 4th Edition.
3. James D Halderman, “Automotive Fuel and Emissions Control Systems”, (2015), Prentice Hall, 4th Edition
4. Klingenberg H, “Automobile Exhaust Emission Testing”, (2012), Springer.

Mode of assessment: CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE503L	Automotive Electrical and Electronics	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To impart basic knowledge of vehicle electrical and electronic systems to the student.
2. To develop an understanding on the power generation, storage and utilization processes involved in the vehicle.
3. To bring an understanding on the communication and networking among the electrical and electronic systems in the vehicle.
4. To enable the students to investigate and design the sensing and actuation processes involved in the vehicle.

Course Outcome:

1. Gain the knowledge of construction and working of batteries
2. Understand the working of charging and starting systems
3. Gain the knowledge and skills of the automotive wiring design and ignition system
4. Acquiring the sensing technique and working of automotive sensors
5. Understand the working of engine management system and other electronic control unit in the vehicle
6. Gain the skills on the recent development in the area of automotive electronic and electrical systems
7. Understand the real-time of working of the various sensors with its characteristic features

Module:1	Battery	6 hours

Battery - Principle and construction of Lead Acid Battery, Choice of battery for automotive applications, Characteristics of Battery, Battery Rating, Capacity and Efficiency.

Module:2	Starting and Charging System and Electric Drives	6 hours

Requirements of Starter Motor, Starter Motor types, construction and characteristics, Starter drive mechanisms, Starter Switches and Solenoids. - Charging system components, Generators and Alternators, types, construction and Characteristics, Voltage and Current Regulation, Cut –out relays and regulators.

Module:3	Wiring and Lighting System	6 hours

Automotive Wiring Harnesses, Insulated and Earth Return System, Positive and Negative Earth Systems, Connectors and its types, Head Lamp and Indicator Lamp construction and working details, focusing of head lamps, Anti–Dazzling and Dipper Details.

Module:4	Sensors and Actuators	6 hours

Engine sensors and actuator: Manifold Absolute Pressure sensor, knock sensor, Coolant and Exhaust gas temperature, Exhaust Oxygen level sensor, Throttle position sensor, accelerator pedal position sensor and crankshaft position sensor, Air mass flow sensor. Solenoids, stepper motors and relays, piezo actuators.
Chassis: - Steering wheel angle sensor, Vibration and acceleration sensors, Pressure sensors, Speed and RPM sensors, torque sensors.

Module:5	Electronic Engine Management System	6 hours

Microprocessor And Microcomputer controlled devices in automobiles, Architecture of an ECU, Electronic engine control: Input, output devices, electronic fuel control system, engine control operating modes, electronic ignition systems, and Spark advance correction schemes.

Module:6	Electric Management System and Dash Board Instrumentation	6 hours

Cruise control system, Antilock braking system, traction control system, electronic suspension system, electronic steering control, transmission control, Airbags, collision avoiding system, low tire pressure warning system. Warning system, driver information

system, instrument cluster ECU, types of indication in the cluster, Bus system, CAN and LIN communication, Horns, wiper system and its types, keyless entry system.		
Module:7	**Ignition System**	**6 hours**
Spark Plugs, Constructional details and Types, Battery Coil and Magneto–Ignition System Circuit details and Components, non–Contact–type Ignition Triggering devices, Capacitive Discharge Ignition, Distributor–less Ignition System.		
Module:8	**Contemporary Issues**	**3 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Tom Denton, Automobile Electrical and Electronic systems (2017), 5th Edition., Rouletedge, Taylor & Francis Group
Reference Books	
1.	William B.Ribben, Understanding Automotive Electronics (2017), 8th edition., Elsevier Science.
2.	Bosch Automotive Electrics and Automotive Electronics, 2014, ISBN: 978-3-658-01783-5
3.	J. D. Halderman, and C. D. Mitchell, 2005. Automotive electricity and electronics. 6th Edition., Pearson/Prentice Hall.

Mode of Evaluation: CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE503P	Automotive Electrical and Electronics Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. The importance of learning automotive electrical and electronics systems
2. The purpose of various electronic sensor and actuator systems in any modern automotive.

Course Outcome

1. Determine proper operation of various sensors by monitoring their signals.
2. Explain the purpose of passive restraint systems

Indicative Experiments	
1.	Study of Advanced Diagnostic Tools
2.	Temperature Measurement-Thermocouple, Thermister, RTD, IR
3.	Pressure and Force Measurement
4.	Strain Measurement
5.	Speed Measurement
6.	Vibration Measurement
7.	Humidity Measurement
8.	Light Intensity Measurement
9.	Microcontroller based stepper and servo motor control
10.	Basic Automotive Electrical Wiring
Total Laboratory Hours	**30 hours**

Text Book(s)

1.	Hollembeak, Barry. Today's Technician: Automotive Electricity and Electronics, Classroom and Shop Manual Pack. Cengage Learning, 2014.

Reference Books

1.	De Silva, Clarence W. Sensors and actuators: control system instrumentation. CRC Press, 2007.
2.	Jurgen, Ronald K. "Automotive electronics handbook." (1999) 2nd Edition.

Mode of assessment: CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE504L	Automotive Transmission System	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To provide the students with sufficient background to understand the need for various modern drivelines and their components.
2. To enable the students to understand different types of clutches and gearboxes.
3. To help the students design the car and truck gearboxes.

Course Outcome

Upon Successful Completion of this course, students will be able to

1. Identify and also select a suitable clutch for a given vehicle.
2. Analysis and design of the gearbox for any given vehicle.
3. Possess the knowledge of various special purpose vehicle transmission systems.
4. Explain the need and function of a semi and fully automatic transmission system.
5. Comprehend and also develop new transmission systems.
6. Understand the latest technology in transmission systems, including hybrid electric vehicles.

Module:1	Clutch	7 hours

Introduction, Necessity of clutch in an automobile, types of clutches, Single plate clutch, multi-plate clutch, cone clutch, centrifugal clutch, hydraulic assisted clutches, vacuum assisted clutch. Clutch - adjustment, Clutch troubles and their causes, requirements of a clutch, Clutch material, clutch lining.

Module:2	Fluid coupling	4 hours

Fluid coupling: advantages and limitations, construction details, torque capacity, slip in the fluid coupling, performance characteristics. Means used to reduce drag torque in fluid coupling.

Module:3	Tractive Performance	7 hours

Various Resistances to Motion of the Automobile, Traction, tractive effort Performance curves, acceleration grade ability, drawbar pull.

Module:4	Gearbox	6 hours

The need for transmissions, Necessity of gearbox, Constructional details of Sliding-mesh gear box, Constant-mesh gearbox, Synchromesh gear. Desirable ratios of 3speed & 4speed gearboxes. Transfer case, overdrive.

Module:5	Driveline	5 hours

Effects of driving thrust and torque reaction. Hotchkiss drive. Torque tube drive, radius rods. Propeller shaft. Universal joints. Final drives – different types, double reaction final drive. Two-speed rear axle. Rear axle construction – full floating, three-quarter floating, and semi-floating arrangements. Differential – conventional type, non-slip type. Differential locks.

Module:6	Automatic transmission	6 hours

Hydrodynamic Drive - Torque Converter: Principal of torque conversion, single, multi-stage and polyphase torque converters, performance characteristics, constructional and operational details of typical hydraulic transmission drives. Leyland, White Hydro torque drives.

Automatic transmission: Planetary gearboxes - Ford T-model, Cotal and Wilson Gear box: Epicyclic transmission, hydrostatic transmission, continuously variable transmission: Types – Belt and Toroidal - Relative merits and demerits when compared to conventional transmission.

Module:7	Semi-automatic transmission	8 hours

Hydrostatic drives: advantages and disadvantages, principles of hydrostatic drive systems, construction and working of typical hydrostatic drives, Janney Hydrostatic drive. Electrical

drives: advantages and limitations, principles of Ward Leonard system of control Modern electric drive for buses and performance characteristics. Semi automatic transmissions – Dual clutch transmission, Direct shift gearbox, Multimode manual transmission, Tiptronic transmission, Paddle shift gearbox.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Robert fisher, Kücükay, F., Jürgens, G., Najork, R., Pollak, B, "The Automotive Transmission book", 2015, Springer- ISBN 978-3-319-05263-2.
Reference Books	
1.	Song M., Automotive Transmissions Design Theory And Applications 2021, Springer-9789811567056.
2	Naunheimer, H., Bertsche, B., Ryborz, J., Novak, W. "Automotive Transmissions-Fundamentals, Selection, Design and Application", 2011,Springer-ISBN 978-3-642-16214-5.
Mode of Evaluation: CAT, Written assignment, Quiz and FAT	

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE505L	Vehicle Dynamics	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To enable students to understand the role of tire characteristics and its mechanics for vehicle dynamics
2. To enable the students to understand vehicle performance, handling and ride aspects and the issues involved in it such as braking, traction, road holding, vehicle control and stability
3. To prepare the students to understand significance of steering and suspension mechanisms for vehicle dynamics.
4. To demonstrate how to apply fundamentals of vibrations and acoustics for vehicle NVH perspective along with importance of modal analysis and transfer path analysis

Course Outcome:

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

1. Predict the necessary forces and moments during tire/road interaction through various tire models for vehicle dynamic simulations.
2. Compute maximum traction, optimum braking distribution and stability of the vehicle of two and three axle vehicles
3. Demonstrate the application of fundamental governing equations for longitudinal, lateral and vertical dynamics and able to use state space approach.
4. Compute steady state and transient response of vehicle during cornering.
5. Outline the role of suspension in roll over stability.
6. Evaluate the role of suspension for vibration isolation, rattle space and road holding using appropriate mathematical models.
7. Identify the current literature and the necessity of modern tools for vehicle development

Module:1	Tyre Mechanics	9 hours

Introduction to Vehicle Dynamics- Vehicle and Tyre co-ordinate systems, Tyre types and construction-Tyre forces and moments-Tyre-slip & skid phenomenon grip and rolling resistance-Cornering properties of tyres- Tyre models- Julien's tyre model for combined tractive and braking effort, Temple & Von Schippe approach of tyre string model for cornering force, Friction Ellipse concept, Magic Formula tyre model for steady state motion. Tyre performance on wet surfaces-Ride properties of tyres.

Module:2	Longitudinal Dynamics	6 hours

Performance characteristics-Maximum tractive effort-Power plant and Transmission characteristics. Braking performance-Study of tractor-semitrailer-Anti lock brake system-Traction control system

Module:3	Lateral Dynamics	6 hours

General frame work and governing equations for vehicle in space-Necessary assumption for deducing governing equations for ground vehicles. Bicycle Model-Low speed turning-High speed cornering-State space approach-Steaty state handling characteristics of two axle vehicle- neutral steer-understeer-oversteer. Steady state gains from Bicycle Model duirng pure cornering. Vehicle handling tests.

Module:4	Vehicle stability	4 hours

Yaw plane stability and steering conditions-Understeer gradient – Handling response of a vehicle- Lateral transient response-Mimuro plot-Roll over stability analysis.		
Module:5	**Steering and Suspension Mechanisms**	**6 hours**
Steering geometry and mechanism, steering mechanism optimization- Four wheel steering-Solid Axle suspension-Independent suspension-Roll center and Roll axis-Roll mement distribution-Car tyre relative angles-Caster theory- Role of suspension and nonlinearity of tyres on vehicle roll and its effect on Understeer co-efficient		
Module:6	**Vertical Dynamics**	**6 hours**
Vehicle ride characteristics-Human response to vibration-Vehicle ride models-Quarter car model- pitch and bounce model- Suspension performance for ride-vibration isolation,suspension travel, Road holding. Active and Semi-active suspensions. Introduction to random vibration. ISO road roughness and road profiles-RMS acceleration of sprung mass of vehicle for random road excitation.		
Module:7	**Introduction to Noise, Vibration and Harshness**	**6 hours**
Fundamentals of Acoustics, Noise and Vibrations. Frequency response functions-Modal analysis- Transfer path analysis- Single reference- Multi reference analysis.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours	**45 hours**

Text Book(s)	
1.	J. Y. Wong (2008), “Theory of Ground Vehicles”, 4th Edition, John Wiley and Sons Inc., New York, 2008
2.	Thomas D Gillespie, Fundamentals of Vehicle Dynamics, 2nd Revised Edition, SAE International, Warrendale, 2021
Reference Books	
1.	Reza N Jazar “Vehicle Dynamics: Theory and Application”, 3rd Edition, Springer International Publishing AG, Switzerland, 2017
2	Katsuhiko Ogata, “Modern Control Engineering”,5th Edition, Prentice Hall,Pearson,2015.
3.	C. Sujatha, “Vibration and Acoustics: Measurements and Signal Analysis”, McGraw Hill Education (India) Private limited, 2017.
Mode of Evaluation: CAT, Written assignment, Quiz and FAT	

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE505P	Vehicle Dynamics Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

To prepare students to carry out real-time and virtual experimental measurements for vehicular system and its subsystems.

Course Outcome

Upon Successful Completion of this Lab course, Students will be able to

1. Understand and use the measurement systems such as data acquisition system, various types of exciters, accelerometers, microphones in real time experiments.
2. Carry out virtual testing using CARSIM software to quantify its performance, handling and ride quality.

Indicative Challenging Experiments

1.	Preparation of test set up for spectral testing	3 hours
2.	Experimental Modal Analysis a wheel rim.	3 hours
3.	Quantification of structural transfer function for NVH study of a passenger car	3 hours
4.	Quantification of Vibro-acoustic transfer function for NVH study of a passenger car	3 hours
5.	Preparation of test set up for signature testing	3 hours
6.	Interior noise measurement in a passenger car during different operating condition	3 hours
7.	Whole body vibration measurement of an occupant in a passenger car	3 hours
8.	Mathematical modelling of ride models for suspension performance using Matlab/Simulink	3 hours
9.	Virtual vehicle testing & stability analysis using CARSIM	3 hours
10.	Vibro-acoustic analysis of a component using Simcenter 3D	3 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment: CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE506L	Hybrid Electric Vehicles	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To provide the students with sufficient knowledge on series, parallel and full hybrid architectures of automobile vehicles.
2. To enable the students to understand the concept of electric drive trains, hybrid architectures and hybrid power plant specifications.
3. To help the students to understand the concept of sizing the drive system, energy storage and their alternatives, energy management and control system.
4. Analyze the various power electronics implemented in the electric vehicles.
5. To introduce the concepts of various controllers and charging system in EV.

Course Outcome

1. Possess the knowledge of series, parallel, plug-in and full hybrid vehicle architectures.
2. Acquire, analyze, configure and control of DC, induction, permanent magnet, switch reluctance motor drives and compute their efficiency.
3. Explain the requirements and outline the working of power electronics in EV systems
4. Understand about working principle and features of EV battery system
5. Describe the latest technologies present in a charging system for EV

Module:1	Hybrid vehicle architectures	5 hours

Hybrid vehicle architectures – range extender and full hybrid systems – Parallel hybrid architectures Plug-in hybrid architectures – Commercially available electric and hybrid vehicles Series configuration locomotive drives – series parallel switching – load tracking architecture – Pre transmission parallel and combined configurations – Mild hybrid – power assist – dual mode power split – power split with shift

Module:2	Energy management and control for HEV	6 hours

All electric range – Engine dominant blended strategy – Electric dominant strategy – Hybrid vehicle control strategies – Introduction to energy management strategies – classification of energy management strategies – rule based and optimization strategies – real-time working of energy management system in HEV

Module:3	Electric vehicle architectures	6 hours

Basic concept of electric traction – introduction to various electric drive-train topologies – power flow control in electric drive-train topologies – fuel efficiency analysis – Electric Propulsion unit – Introduction to electric components used in electric vehicles – Transmission types for EV – Power Flow Control in Electric Drivetrain – Positioning of Motors – Vehicle Performance – Tractive Effort

Module:4	Electric Motors in EV	7 hours

Types of Motors in EV – Characteristics features of EV motors – Torque Speed Characteristics – Construction and operating principle – DC Motor – Brushless DC Motor – BLDC Motor Control – Switched Reluctance Motor – AC Induction – PMSM – Advantages and comparison of motors – Drive system Efficiency – EV Motor Cooling

Module:5	Power Electronics in EV	6 hours

Electric Drive Components – Introduction to Power electronic components – Power Electronic Switches 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

Module:6	Electric Vehicle batteries	7 hours

Battery range – Battery types (Lithium ion, Metal air, etc) – Battery parameters – Battery Terminology (SOC, SOH,DOC, etc) – Construction of Lithium ion (Li) battery – Working –

Characteristics features – Battery Pack – Traction Battery Pack design – Battery Temperature, Heating and Cooling Needs – Thermal Management of Batteries – Types – Characteristics features and working. Battery Management System (BMS) – Architecture of BMS – Design Consideration of BMS Battery State Estimation Methods		
Module:7	**Electric Vehicle Charging**	**6 hours**
EV charging technology – Types of charging systems – Fundamental principle of wireless charging – Wireless charging technologies – Comparison between Conductive and Inductive charging schemes of EV – Wireless charging methods for EVs.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Tom Denton, (2020) Electric and Hybrid Vehicles. Routledge Publication.
2.	Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. M. (2018). Modern electric, hybrid electric, and fuel cell vehicles. CRC press.
Reference Books	
1.	Patel, N., Bhoi, A. K., Padmanaban, S., & Holm-Nielsen, J. B. (Eds.). (2021). Electric vehicles: modern technologies and trends. Springer.
2.	Soylu, S. (Ed.). (2011). Electric vehicles: modelling and simulations. BoD–Books on Demand.

Mode of Evaluation: CAT, Written assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MMAT502L	Advanced Mathematical Methods	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To provide the students with sufficient exposure to advanced mathematical methods and tools that are relevant to engineering research.
2. Improving the computational skills of students by giving sufficient knowledge of analytical and numerical techniques useful for solving problems arising in Mechanical Engineering.
3. Imparting the knowledge of real time applications of Autonomous systems, Non-linear systems of ordinary differential equations and partial differential equations.

Course Outcome:

1. Distinguish and analyse a variety of tools for solving linear systems and finding eigenvalues of these systems.
2. Derive and use the numerical techniques needed for the solution of a given engineering problems
3. Understand and correlate the analytical and numerical methods
4. Demonstrate their ability to write coherent mathematical proofs and scientific arguments needed to communicate the results obtained from differential equation models.
5. Demonstrate the understanding of how physical phenomena are modelled by partial differential equations

Module:1	Eigenvalue Problems	5 hours

Standard Eigen value problems–Eigenvalues and Eigenvectors–Gerschgorin Circles theorem–Rutishauser method, Power method, Inverse Power method.

Module:2	Iteration Methods	6 hours

Sturm sequence, Jacobi method, Given's method, Householder method, Deflation, Lanczo's method.

Module:3	Calculus of Variations	9 hours

Euler-Lagrange's equation –Isoperimetric problems, Rayleigh–Ritz method - Galerkin method.

Module:4	System of First Order Ordinary Differential Equations	6 hours

Linear Systems - Homogeneous linear systems with constant coefficients - Autonomous systems - Phase Plane Phenomena - Critical Points - Stability for linear systems.

Module:5	Nonlinear systems	6 hours

Simple critical points of nonlinear systems-Stability by Liapunov's method –

Non- Linear Mechanics: Conservative systems.

Module:6	Partial Differential Equations	5 hours

Classification of Second-Order Partial Differential Equations, Significance of characteristic curves, Canonical Form, Sturm–Liouville problems and Eigen function expansions.

Module:7	Wave equation	6 hours

Displacements in a long string – a long string under its weight – a bar with prescribed force

on one end – free vibrations of a string. Method of Separation of variables, Solution by method of Laplace transforms		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1	Differential Equations: Theory, Technique and Practice, G.F. Simmons, S. G. Krantz, Tata Mc GrawHill Publishing, 2012. (Topics from Chapters 10, 11)
2	Elements of Partial differential equations, Ian N. Sneddon, Dover Publications, New York, 2006. (Topics from Chapters 3, 5)
3	Numerical Methods for Scientific and Engineering Computation, M. K. Jain, S. R. K. Iyengar, R. K. Jain, New Age International publishers, 7th edition, New Delhi, 2019. (Topics from Chapter 3, 7)
4	Introductory Methods of Numerical Analysis, S. S. Sastry, PHI Pvt. Ltd., 5th Edition, New Delhi, 2015. (Topics from Chapter 11)
5	The Calculus of Variations, Bruce van Brunt, Springer, 2004. (Topics from Chapters 2, 4, 5)
Reference Books	
1	Differential Equations and Dynamical Systems, Lawrence Perko, 3rd ed., Springer-Verlag, 2001.
2	An introduction to Ordinary Differential Equations, James C. Robinson, Cambridge University Press, New York, 2008 (4th print).
3	Elementary Applied Partial Differential Equations, Richard Haberman, Prentice Hall International, 1998.
4	Numerical Analysis, R. L. Burden and J. D. Faires, 10th Edition, Cengage Learning, India edition, 2015.

Mode of Evaluation: CAT, Assignment, Quiz, FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE601L	Engine Design and Development	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

To make students who take this course be able to

1. To provide sufficient background of engine design and development.
2. To broaden the understanding constraints in the engine design.
3. To gain the basic knowledge of the concepts in engine design and development.
4. To broaden the understanding of Sizing and design of major components
5. To enable the students to apply the knowledge modern pollution systems

Course Outcome

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

1. Possess the fundamental knowledge of engine component design and development.
2. Apply the concepts considering material, loads on engine component design and development.
3. Analyze the Lubrication and crankcase breathing system capacity
4. Impart the knowledge to develop the pollution control system.

Module:1	Engine Maps, Customers and Market	5 hours

Key customer requirements - Regulatory and technological constraints as well as application needs - Translating customer requirement to technical profile - Packaging, weight, cost, performance, reliability / durability, regulatory, production volume, life cycle, quality, operating environment – Engine Mapping – Developing reliable and durable engine – Wear and failure mechanisms – Engine Development Process

Module:2	Engine layout	7 hours

BMEP- Power torque curve – displacement – number of cylinders - cylinder arrangement – inline, V, opposed – Bore spacing - Bore to stroke ratio optimization – Combustion chamber design - Valve arrangement - Cooling type- air cooled-liquid cooled – oil cooled – Lubrication and wear – Fuel system – injectors – Fuel Pumps - Spark Plug

Module:3	Block and Cylinder Head	5 hours

Cylinder Block – Choice of Materials and Manufacturing - Monolithic blocks – Cast Iron & Aluminium blocks – Design constraints – Cylinder block layout design – Cylinder head layout design – Block and head mating – head gasket – Thermal loads – Engine bearing design – Design of Piston – Types – Material Selection

Module:4	Sizing of major engine components	8 hours

Connecting Rod – Material Selection – Connecting Rod Design - Crank Shaft Sizing – Balancing – Bearing Load and Design - CAM shafts – location - CAM Drive type and configuration – Wear Characterization and Design

Module:5	Cylinder head	7 hours

Head Design - Valve sizing Intake and Exhaust valves- Valve train - Intake port swirl and tumble, Intake port and manifold length - Exhaust port and exhaust manifold length

Module:6	Cooling and Lubrication systems	5 hours

Lubrication - Crankcase Capacity - Pump type, sump size and location, Lubrication circuit, Oil drain back and scavenging, Crankcase ventilation, windage, breathing
Cooling circuit, Pump capacity and temperature control, Circuit design and analysis

Module:7	Fly Wheel and Engine Accessories, Pollution control devices	6 hours

Flywheel sizing - Accessory Systems - Alternator, Starter and Compressor (Air, HVAC) - Additional drives (Power Steering Hydraulic Pump)- Power take off - Design of Catalytic

Converters – Particulate Traps - EGR			
Module:8	**Contemporary Issues**		**2 hours**
	Total Lecture hours:		**45 hours**
Text Book(s)			
1.	Kevin Hog and Brain Dondlinger “Vehicular Engine Design”, 2016 Springer Publications		
Reference Books			
1.	Engineering Know-How in Engine Design (Part 1 to 24), SAE, USA.		
2.	SAE SP-1071, Applications and Developments in New Engine Design and Components, SAE Publications, USA		
Mode of Evaluation**:** CAT, Written assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE602L	Battery and Fuel Cell	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. To broaden the importance of Battery and Fuel cell.
2. To enable the students to understand the importance of Battery and Fuel cell.
3. To assist the students to know about Battery performance and selection Battery and Fuel cell.
4. To gain the basic knowledge about Lithium-Ion Batteries.
5. To help the students to identify the Advanced Batteries for Electric Vehicles

Course Outcome:

Upon Successful Completion of this course ,Students will be able to

1. Acquire and analyze the various type's battery and Fuel cell.
2. Characterize various Battery and Fuel cell performance.
3. To maintain and inspect various Battery types and Fuel cell.
4. To develop battery and fuel cell for the modern requirements
5. To apply the advanced batteries for electric vehicles

Module:1	Introduction	5 hours

Introduction to Battery - Battery types - Fundamentals of electrochemistry - galvanic and electrolytic cells, differences -Thermodynamics of electrochemical cells - Definition, derivation of Nernst equation

Module:2	Battery performance and selection	6 hours

Battery Performance Measurements, Factors Affecting Battery Performance - Battery Standardization - Battery Design – Battery Management System - Battery Fault Detection, Maintenance and Test - Battery Installation - Selection of Battery for Automotive application.

Module:3	Lead acid battery	8 hours

theory of operation – cell construction – battery construction – Discharge performance – Charge methods – Temperature effects and limitations – service life – storage characteristics – maintenance requirements – failure modes

Module:4	Lithium-Ion Batteries	6 hours

General Characteristics - Chemistry - Construction of Cylindrical and Prismatic Li-Ion Cells and Batteries - Li-Ion Battery Performance - Charge Characteristics of Li-Ion Batteries - Safety Testing of Cylindrical C/LiCoO2 Batteries - Polymer Li-Ion Batteries - Thin-Film, Solid-State Li-Ion Batteries - Conclusions and Future Trends

Module:5	Advanced Batteries for Electric Vehicles	6 hours

General Characteristics Description of the Electrochemical Systems, Cell Design and Performance Characteristics of - Metal/Air Batteries - Zinc/Bromine Batteries - Sodium-Beta Batteries - Lithium/Iron Sulfide Batteries

Module:6	Fuel cells	6 hours

Introduction and overview of fuel cells - technology: low and high temperature fuel Cells - Fuel 40 cell reaction kinetics: Introduction to electrode kinetics – performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, fuel cell power plant: fuel processor, fuel cell power section, power conditioner

Module:7	Types of Fuel Cells	6 hours

Fuel cell types: alkaline fuel cell, polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, Direct Methanol Operated fuel cells-Geometries of solid oxide fuel cells: planar, tubular, Types of solid oxide fuel cells: High temperature, intermediate temperature ,Single chamber solid oxide fuel cells, Problems with fuel cells.

Module:8	Contemporary issues:	2 hours

	Total Lecture hours:		**45 hours**
Text Book(s)			
1.	David Linden and Thomas B. Reddy — Hand Book of Batteries Third Edition‖ , McGraw-Hill, NY, 2010		
Reference Books			
1.	Robert A. Huggins Advanced Batteries - Material Science Aspects, Springer Publications, NY 2009		
2.	D.A.J. Rand, P.T. Moseley,J. Garche , C.D. Parker, Valve Regulated Lead Acid Batteries, Elsevier Publications, USA, 2004		
Mode of Evaluation: CAT, Written assignment, Quiz and FAT			
Mode of assessment:			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE603L	Vehicle and Engine Testing	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To understand and interpret EEC, ECE, FMVSS, AIS and CMVR regulations related to homologation of vehicles for both domestic and export. Understand the requirements, guidelines, various parameters, test instruments and test tracks to perform homologation tests
2. To understand the requirements and guidelines of Static and Dynamic testing regulations of the vehicle and vehicle components and perform the tests.
3. To understand and gain knowledge about various safety protocols, classification of the vehicles and testing regulations related to HEV, EV and retrofitted vehicles
4. Understand the regulations and testing protocols of vehicle's lighting and signaling systems

Course Outcome

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

1. Classify the vehicle and identify its regulation according to the type proposed in CMVR
2. Perform the Static and Dynamic tests according to IS and AIS regulations and make an analysis report
3. Understand the safety protocols of vehicle's energy storage systems and perform various tests to meet CoP
4. Understand the safety systems of EV sub systems and perform various tests to meet CoP
5. Classify the vehicle for retrofitting (both HEV and EV), identify its regulation and perform various tests
6. Perform various tests on vehicle's lighting and signaling devices

Module:1	CMVR and Homologation	6 hours

Classification of Vehicles, Homologation and its types, Regulations overview (EEC, ECE, FMVSS, AIS, and CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks

Module:2	Static Tests	6 hours

Static Testing - Tyre Tread Depth Test, Vehicle Weightment (IS:11825), Horn installation (IS:15796), Rear view mirror installation (AIS:002), Tell Tales (AIS:126), External Projection, Wheel Guard, Arrangement of Foot Controls For M1 Vehicle, Angle & Dimensions Measurement of Vehicle – Drive away chassis

Module:3	Dynamic Tests	7 hours

Dynamics Testing: Hood Latch, Gradeability (AIS:003), Pass-by Noise (IS:3028), Interior Noise (AIS:020), Turning Circle Diameter & Turning Clearance Circle Diameter, Cooling Performance, Speedo-meter Calibration (IS:11827), Range Test, Maximum Speed, Acceleration Test, Coast-down test (IS:14785), Brakes Performance ABS Test (IS:14664), Broad band / Narrow band EMI Test. Engine power test (petrol & diesel), Indian driving cycle, Vehicle mass emission, Evaporative emission (petrol vehicles), Vehicle Crash Testing

Module:4	Electric Vehicle Storage system testing	5 hours

Safety Requirements of Traction Batteries (AIS : 048) - Electrical Tests - Short Circuit Test - Overcharge Test - Mechanical Tests- Vibration Test - Shock Test - Roll-Over Test (Battery Module) - Penetration Test (Cell Level or Battery module) - Battery Parameters - Capacity Test - Charge Retention Test - Conformity of Production (COP) - Rated Capacity - Battery Performance Testing (ISO:12405,18243,15118)

Module:5	**Electric Vehicle and Retrofit Testing**	**7 hours**

Requirements of a vehicle with regard to its electrical safety (AIS: 38) - Safety requirements with respect to the electric power train of motor vehicles of categories as defined in Rule 2 (u) of CMVR - Safety requirements with respect to the Rechargeable Electrical Energy Storage System (REESS), of motor vehicles categories as defined in Rule 2 (u) of CMVR - Measurement of Electrical Energy Consumption (AIS:39) - Measurement of Max Power and 30 min Power (AIS:041) - Method of Measuring the Range for Electric Vehicles (AIS:040) – Electromagnetic Compatibility of the Motor Vehicle (AIS: 003 – part 3) - CMVR Type approval for Electric Vehicles (AIS:049)

CMVR type approval for HEV (AIS:102 part-1, part-2), Type approval of Vehicles retrofitted with HEV (AIS:123 part-1&2), Test for EV kit for Conversion (AIS:123 part 3), Test for Electric Vehicle Conductive AC Charging System (AIS:138), and Test for Electric vehicle conductive DC charging system (AIS:138)

Module:6	**Engine Testing**	**6 hours**

Engine Testing and Performance: Automotive and stationary diesel engine testing and related standards. Engine power and efficiencies. Range Test, Maximum Speed, Acceleration Test, Coast-down test, Engine power test (petrol & diesel), Indian driving cycle, Vehicle mass emission, Evaporative emission (petrol vehicles)

Module:7	**Lighting and Signaling Devices**	**6 hours**

Vehicle Lighting Testing (AIS:009, AIS:010, AIS:037): Installation requirement for lighting – front and rear, signaling and reflective devices Installation, Conspicuity and Reflective Marking, Photometry Test: Performance requirement for lighting, signaling and reflective devices - Head lamp, Front lamp, direction indicator lamp, signaling lamp and Warning triangles

Module:8	**Contemporary Issues**	**2 hours**

	Total Lecture hours:	**45 hours**

Text Book(s)

1.	A.J.Martyr, M.A.Plint, Engine Testing Theory and Practice, SAE International, Third Edition, 2007.

Reference Books

1.	ISO test standards – 26262, 12405, 18243, 15118, 18243
2.	Automotive Industry Standards test standards (AIS)– 003, 004, 008, 009, 010, 014, 020, 037, 038, 039, 040, 041, 048, 049
3.	Indian Standards (IS) – 14785, 14664, 3028, 15796, 14495, 15627, 1884, 7079, 8654
4.	Safety Regulations – Society of Indian Automotive Manufacturers
5.	ECE and EEC regulations / Standards

Mode of Evaluation**:** CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE604L	Vehicle Maintenance and Diagnostics	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To provide the students with sufficient background to understand the importance of vehicle maintenance, its types and their diagnostics techniques.
2. To equip students with the knowledge of engine and sub-system maintenance.
3. Develop the students to have in-depth knowledge about on-board diagnostics, chassis system diagnostics and electrical system diagnostics.

Course Outcome:

1. Possess the knowledge of overall vehicle maintenance and its types, on and off-board diagnostics and engine and its sub-system maintenance.
2. Demonstrate the application of oscilloscope and on-board diagnostics for automobiles.
3. Provide an in-depth knowledge about the diagnostics of engine sub-systems like battery charging and starting systems, lubrication systems air supply and exhaust systems.
4. Gain the knowledge of chassis system maintenance and various diagnostics techniques applied to brakes, steering and suspension systems.
5. Acquire and analyze the maintenance and diagnostics of electrical system including HVAC, cruise control diagnostics, airbags diagnostics, advanced fault diagnostics and remote diagnostics.

Module:1	Introduction	7 hours

Need for maintenance, types of maintenance: preventive and breakdown maintenance, requirements of maintenance, preparation of check lists. Inspection schedule, maintenance of records, log sheets and other forms, safety precautions in maintenance: General safety, tool safety - Diagnostic Techniques - diagnostic process - diagnostics on paper - mechanical diagnostic techniques - electrical diagnostic techniques - fault codes - on and off-board diagnostics - Data sources

Module:2	Engine maintenance	7 hours

Dismantling of engine components: cylinder head, valve train, cylinder block, connecting rod, piston and crankshaft assembly; cleaning and inspection of engine components, reconditioning of components.

Module:3	Engine subsystem maintenance	7 hours

Servicing and maintenance of fuel system, Engine tune-up, cooling system: water pump, radiator, thermostat. Lubrication system maintenance, Anticorrosion and anti freeze additives

Module:4	Oscilloscope diagnostics and On-board diagnostics	7 hours

Basic equipment - Oscilloscopes - Scanners - Fault code readers - Engine Analyzers - Sensors - Actuators - Ignition System - Other components - A first perspective - Petrol / Gasoline on-board diagnostics monitors - a second perspective

Module:5	Engine Systems	5 hours

Diagnostics of Engine operation - Fuel system - Ignition - Emission - Fuel Injection - Diesel injection - Engine management - Fault finding information - air supply and exhaust systems - cooling - lubrication - batteries - starting system - charging system.

Module:6	**Chassis System – maintenance and diagnostics**	**5 hours**
Servicing and maintenance of clutch, gear box, universal joints, propeller shaft, differential system. Service and maintenance of brake – disc and drum brakes, steering wheel and suspension systems, wheel alignment, vehicle body maintenance - Diagnostics of brakes - anti-lock brakes diagnostics - traction control diagnostics - steering diagnostics - suspension diagnostics		
Module:7	**Electrical System**	**5 hours**
Electronic components and circuits diagnosis - multiplexing - lighting - diagnosing auxiliary system faults - in car entertainment security and communication - body electrical system faults - diagnosing instruments system faults - HVAC diagnostics - Cruise control diagnostics - Air bags and belt tensions diagnostics		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Automotive Technician Training, Tom Denton, Taylor and Francis, New York, 2015
Reference Books	
1.	Automobile Electrical and Electronic Systems : Automotive Technology - Vehicle Maintenance and Repair, Tom Denton, Fourth Edition, Elsevier, New York, 2013
2.	Advanced Automotive Fault Diagnosis: Automotive Technology - Vehicle Maintenance and Repair, Tom Denton, Third Edition, Elsevier, New York, 2012.

Mode of Evaluation: CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE605L	Vehicle Aerodynamics	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To provide the students with sufficient background to understand the aerodynamics of road vehicles.
2. To enable the students to understand the dynamics of the vehicles influenced by aerodynamics.
3. To help the students to understand aerodynamics of vehicles to help in stability, safety and comfort.
4. To teach students how to measure and test vehicles using different techniques.

Course Outcome:

1. Gain the knowledge of basic principles of road vehicle aerodynamics and performance analysis of cars, light trucks and commercial vehicles.
2. Compute the aerodynamics drag, various resistances and to arrive at lesser fuel consumption of vehicles.
3. Possess the knowledge of basic of flow over vehicles and resistance to vehicle motion and analyzing for stability safety and comfort.
4. Predicting the performance of high speed race cars, commercial vehicle aerodynamics and to demonstrate the various measurement and testing techniques used in automobiles.
5. Design, simulate and analyse the flow over cars using computation fluid dynamics technique and to calculate the lift and drag forces through various turbulence models.

Module:1	Introduction to Road Vehicle Aerodynamics	5 hours

Basic principles of road vehicle aerodynamics; evolution of road vehicles; borrowed shapes; streamlining era; parametric studies; one-volume bodies; bathtub bodies; commercial vehicles; motorcycles; shape and detail optimization; futuristic trends; performance analysis of cars and light Trucks.

Module:2	In Motion Dynamics	7 hours

Vehicle equation of motion; aerodynamic drag; tire rolling resistance; climbing resistance; effective mass; traction diagram; acceleration capability and vehicle elasticity; fuel consumption and economy; gear-ratio re-matching; EPA driving cycles – urban, highway, combined; low fuel consumption strategies.

Module:3	Directional Stability, Safety and Comfort	7 hours

Flow field around a vehicle; interior and exterior flows; attached, separated and oscillating flows; aerodynamic forces and moments; cornering and side wind behaviors; stability index; passing maneuvers; spoiler design; safety and aesthetics; water and dirt accumulation; visibility impairment; ventilation, air flow and odor removal. Engine and interior cooling; radiators; HVAC systems.

Module:4	Race Car, High Performance and Commercial Vehicles	6 hours

Race cars: Front wings, Rear wings, Weight distribution, Over steer and Under steer, Center of gravity effects, Slip streaming. Commercial vehicle aerodynamics: Truck Aerodynamics, Improvements in design, Different styles of trailers. Effect of gap between truck and trailer, fairings.

Module:5	Measurement and Testing Techniques	6 hours

Wind tunnel and on-road testing techniques; classification and design of wind tunnels;

instrumentation and data acquisition; wind tunnel components and corrections; road testing methods; cross-wind and engine cooling tests; soiling, water and dirt accumulation, visibility measurements on road; wind noise models, analysis and measurement.		
Module:6	**Computational Fluid Dynamics and Applications**	**7 hours**
Introduction to CFD analysis; CFD vs. experimentation; Fundamentals of fluid mechanics; Continuity, Navier-stokes and energy equations; Modeling and Discretization techniques; basic steps in CFD computation; 3-D structured and unstructured grid generation, mesh smoothing and sensitivity checks; turbulence models; Eddy viscosity and non-eddy viscosity models; RANS and ARSM models; LES and DNS methods.		
Module:7	**Vehicle Aerodynamic Simulation**	**5 hours**
Biomass - processing and usage, forms - municipal solid waste, wood - DME, GTL: Availability, properties, Production Methods, modifications required in CI engines, performance and emission characteristics, storage, handling and dispensing, safety aspects. Challenges.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Theory and Applications of Aerodynamics for Ground Vehicles, (2014) T. Yomi Obidi. Published by SAE with ISBN 978-0-7680-2111-0.
Reference Books	
1.	Competition car aerodynamics, (2015) 3rd edition- Simon McBeath. Published by Veloce Publishing with ISBN 978-1845847760.
2.	Aerodynamics of Road Vehicles, W.H. Hucho, Butterworth and Co, 1998.

Mode of Evaluation: CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	25-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE606L	Vehicle Crashworthiness	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To gain the basic knowledge about Vehicle Crashworthiness and ATDs.
2. To help the students to identify the various testing regulations for Vehicle Crashworthiness.
3. To assist the students to know about vehicle collision models.
4. To broaden the knowledge about the pedestrian safety and vehicle Ergonomic aspects.
5. To study various of vehicle safety systems and Injury mechanisms

Course Outcome:

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

1. Acquire and analyze the various testing procedures of Vehicle Crashworthiness for different
2. Configuration of collision.
3. Formulate various vehicle crashworthiness models
4. Understand the requirement for vehicle safety system for the modern requirements and vehicle ergonomics aspects
5. Use various injury Mechanisms for evaluating crash severity.
6. Suggest appropriate dummies for different crash tests

Module:1	Safety and Crashworthiness	4 hours

Motor Vehicle Safety - The Automobile Structure Materials and Characteristics of Vehicle Structures - Crashworthiness Goals - Crashworthiness Requirements, Achieving Crashworthiness, Crashworthiness Tests, Crashworthiness Models Requirements. Optimization of vehicle structures for crashworthiness – Active and passive safety.

Module:2	Crash Testing Types and Configurations	6 hours

Types of crash, Crash testing standards-FMVSS, EURO NCAP, Test procedures for Full frontal rigid barrier test, Offset frontal barrier test, Side impact crash test, roll over - Tests, Regulatory requirements for crash testing –star ratings- Instrumentation, high speed photography, Image Analysis

Module:3	Vehicle Collision Models	9 hours

Impulsive models- Perfect plastic impact- Perfect elastic impact- Co-efficient of restitution-Central Collision-central head on collision, oblique collision, collision against fixed obstacle, Non central Collision-non-central head on offset collision, Kelvin's theorem, Application of relative motion-Change in vehicle speeds-Total crush energy, Vehicle individual crush energies- Crash severity assessment. Problems involving vehicle collisions.

Module:4	Pedestrian Safety and Ergonomics	6 hours

Importance of Ergonomics in Automotive safety- Locations of controls- Anthropometry-Human impact tolerance- Determination of Injury thresholds, Severity Index, Study of comparative tolerance. Study of crash dummies

Module:5	Vehicle Safety Systems	6 hours

Survival space requirements, Restraint systems used in automobiles - Types of safety

belts- Head restraints, Air bags - Use of energy absorbing systems - Impact protection from steering controls - Design of seats for safety- types of seats-Importance of Bumpers - Damageability criteria in bumper designs - Types of safety glass and their requirements, rearward field of vision in automobiles - Types of rear view mirrors and their assessment - Warning devices - Hinges and latches, etc - External Projections, Door locks & retension systems Rear/front/side under run protection devices		
Module:6	**Injury Mechanisms**	**6 hours**
Head Injury Mechanisms –Brian injury mechanisms-Acute Subdural Hematoma- Neck Injury Mechanisms - Compression Injuries - TensionExtension Injuries- Lateral Bending Injuries- Abdominal Injury Mechanisms-Thoracic –Lumbar Spine InjuryMechanisms-Pelvic Injury Mechanicsms- Injury Mechanisms of the Lower extremity such as Knee joint injuries, Ankle joint injuries, Fractures of the long bone and foot bornes-Low Speed Crush InjuriesHigh Speed Impact Injuries.		
Module:7	**Introduction to Dummies**	**6 hours**
Description of an ATDs-Hybrid II Dummy Family - Hybrid III Dummy Family - CRABI Infant Dummies - Side Impact Dummies - Dummy Harmonization		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Matthew Huang, “Vehicle Crash Mechanics”, CRC Press 2002.
2.	Paul Du Bois, Clifford C. Chou and others, “Vehicle Crashworthiness and Occupant Protection”, American Iron and Steel Institute.2004
Reference Books	
1.	Jorge A.C.Ambrosio, “Crashworthiness Energy Management and Occupant Protection”, International Centre for Mechanical Sciences, Springer Wien New York,2001
2	Narauan Yoganandan, Alan M. Nahum, John W. Melvin, “Accidental Injury Biomechanics and Prevention, Third Edition, Springer,2015
Mode of Evaluation: CAT, Written assignment, Quiz and FAT	

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE607L	Design of Vehicle Drivelines	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To make students understand the different components of driveline systems.
2. To make the students be familiar with the different design aspects of driveline components.
3. To introduce the student to the systematic design procedure adopted in industries.

Course Outcome

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

1. Comprehend the different components of driveline systems.
2. Compute the dimensions of driveline components subjected to static and fatigue loads.
3. Compute the critical dimensions of components in the different transmission types.
4. Encompass the modern design tools being followed in industries.

Module:1	Introduction to Transmission & Driveline Systems	4 hours

Powertrain and driveline systems: clutch, gearbox, hydraulic coupling, torque converter, manual transmission, automatic transmission system, transfer case, differentials, drive shafts and propeller shafts

Module:2	Clutch	6 hours

Single plate clutch, band clutch, multi-disk clutch, clutch design and analysis

Module:3	Powertrain Integration System	7 hours

Various resistances to motion of the automobile, traction, tractive effort, performance curves, acceleration, gradeability, drawbar pull- necessity of gearbox, desirable ratios of 3 speed & 4 speed gearboxes - matching engine and transmission system using road loads and axle loads, total ratio and overall gear ratio- selecting the largest powertrain ratio, selecting the smallest powertrain ratio, selecting the intermediate gears- gearshift - functional requirement – design

Module:4	Automatic Transmission	7 hours

Level of automation, gear shift mode, stepped and continuously variable transmissions, synchronizer gearboxes, epicyclical gearboxes, continuously variable transmission (CVT)- design and analysis of planetary geartrains, gear ratios and clutch engagement schedule, clutch torques in steady-state condition, torque analysis in shifting process

Module:5	Hydrodynamic Transmission	7 hours

Fluid coupling – principles - performance characteristics – advantages – limitations – drag torque – reduction of drag torque. Torque converter - principles - performance characteristics – advantages – limitations – multi and poly stage torque converters

Module:6	Hydrostatic Drive and Electric Drive	6 hours

Hydrostatic drive – various types of hydrostatic transmission – principle - advantages and limitations -comparison of hydrostatic transmission with hydrodynamic transmission- construction and working principle of Janny hydrostatic drive - electric drive- principle of early and modified Ward Leonard control system – advantages and limitations

Module:7	Differentials and Final drives	6 hours

Working principle- friction free differential, differential with internal friction, self-locking differential- final drives - performance limits, transmission ratios - differential gears, differential locks and locking differentials, types of self-locking differential

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**45 hours**
Text Book(s)		
1.	T. Kenneth Garrett, Kenneth Newton and William Steeds, “The Motor Vehicle” 13th Edition, Butterworth -Heinemann Limited**,** London, 2005.	
Reference Books		
1.	Heinz Heisler, “Advanced Vehicle Technology”, second edition, Butterworth – Heinemann, New York, 2002	
2.	Dr. N. K. Giri, “Automobile Mechanics”, Seventh reprint, Khanna Publishers, Delhi, 2005	
Mode of Evaluation: CAT, Written assignment, Quiz and FAT		
Recommended by Board of Studies	27-07-2022	
Approved by Academic Council	No. 67	Date 08-08-2022

Course Code	Course Title	L	T	P	C
MAUE608L	Noise, Vibration and Harshness	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To help the students to understand the different sources of noise from automobiles, including engine noise, vehicle structural noise, aerodynamic noise, exhaust noise, and their reduction techniques
2. To enable the students to identify the role of NVH engineers in determining the source of noise and vibration, noise quality, and development stages of a new vehicle.
3. To assist the students with sound measurement, single degree freedom of vibration, test facilities for measuring noise and vibration, and processing the noise signals.

Course Outcome

1. Characterize various sources of automotive noise and their reduction in automobiles
2. Possess the knowledge of the role of NVH engineers in a new vehicle program
3. Identify various sound and vibration measurement methods, including transient and Steady-state response of a single degree of freedom applied to vehicle systems.
4. Acquire the hands-on experience of using semi-anechoic rooms, wind tunnels, and rolling roads simulators to measure various types of noise and vibrations.
5. Outline the role of transducers, acoustics holography, and various instrumentation Employed for analyzing the NVH of vehicle systems
6. Compute sampling, statistical, and frequency analysis of various data obtained during NVH measurements.

Module:1	**Automobile noise pollution**	**5 hours**
Automobiles Noise pollution - Engine Noise, Transmission Noise, Vehicle structural Noise, Aerodynamics noise, Exhaust Noise.		
Module:2	**NVH in the Automotive Industry**	**6 hours**
Sources of noise and vibration. Design features. Common problems. Marque values. Noise quality. Pass-by noise requirements. Target vehicles and objective targets. Development stages in a new vehicle programme and the altering role of NVH engineers.		
Module:3	**Human sensitivity**	**5 hours**
Automotive **s**ound measurement. Human sensitivity and weighting factors related to NVH. Combining sound sources, Acoustical resonances. Properties of acoustic materials.		
Module:4	**Vibration**	**7 hours**
Sources of vibration in automotive, Transient and steady-state response of one degree of freedom system applied to vehicle systems. Transmissibility, Magnification factor. Modes of vibration analysis.		
Module:5	**Test Facilities and Instrumentation**	**7 hours**
Laboratory simulation: rolling roads (dynamometers), road simulators, semi-anechoic rooms, wind tunnels, etc. Transducers, signal conditioning and recording systems. Binaural head recordings. Sound Intensity technique, Acoustic Holography, Statistical Energy Analysis		
Module:6	**Signal Processing**	**6 hours**
Sampling, aliasing and resolution. Statistical analysis. Frequency analysis. Campbell's plots, cascade diagrams, coherence and correlation functions.		
Module:7	**NVH control Strategies & comfort**	**7 hours**
Source ranking. Noise path analysis. Noise reduction in Automobiles. Vibration control methods, Design of Experiments, Optimization of Dynamic characteristics. Vibration absorbers and Helmholtz resonators. Active control techniques.		
Module:8	**Contemporary Issues**	**2 hours**

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Anton FuchsEugenius NijmanHans-Herwig Priebsch, Automotive NVH Technology, 2016, springer.
2.	István L. Vér, Leo L. Beranek, Noise and Vibration Control Engineering: Principles and Applications, 2006, John Wiley.
Reference Books	
1.	M. L. Munjal, 2014, Noise and Vibration Control, World Scientific Press: Singapore
2.	Norton M P, Fundamental of Noise and Vibration, Cambridge University Press, 2003.

Mode of Evaluation: CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE608P	Noise, Vibration and Harshness Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To acquire hands-on experience by carrying out virtual and experimental vibration and noise measurements on a vehicular level and its subsystems.

Course Outcome

1. Understand the vehicle vibration and noise measurements systems such as accelerometers, microphones, and data acquisition devices in real-time experiments.
2. Develop knowledge in analyzing automotive vibration and noise
3. Acquire hands-on experience using anechoic rooms and rolling road simulators to measure various noises and vibrations.

	Indicative Experiments
1.	NVH simulation on simple automotive system. (Ex :Simcenter 3D / MATLAB).
2.	EV/HEV NVH Simple simulations (Ex : Simcenter 3D / MATLAB).
3.	Electric vehicle sound quality measurement at different locations.
4.	Engine vibration response analysis at different parts using accelerometers.
5.	Interior noise measurement in an automotive cabin using microphones.
6.	Radiated noise measurement of different vehicle systems sound level meter.
7.	Structural vibration measurement using vibro meter.
8.	Simple composite automotive part vibration measurement at different end conditions using accelerometers.
9.	Simple composite automotive part noise measurement at anechoic rooms using microphones.
10	Automotive chassis vibration measurement using accelerometers/vibrometer.
11.	Drive line NVH performance analysis
11.	Demonstration of acceleration sensor instrumentations and preparation for real-time vibration testing.
12.	Demonstration of noise sensor instrumentations and preparation for real-time noise testing.
	Total Laboratory Hours **30 hours**

Mode of assessment: CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE609L	Computational Fluid Flow and Heat Transfer	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

The objective of this course is to

1. Provide the students with sufficient background to understand the mathematical representation of the governing equations of fluid flow and heat transfer.
2. Enable the students to understand the fundamental concepts of different discretization techniques.
3. Expose students to the computational complicities on various turbulence models.

Course Outcome

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

1. Apply mathematics and engineering fundamentals to identify the nature of complex fluidflow and heat transfer problems and to formulate governing equations to represent them.
2. Identify and formulate the appropriate discretization techniques based on the mathematical nature of the governing equations.
3. Solve fluid flow and heat transfer problems (diffusion) using finite difference method.
4. Solve fluid flow and heat transfer problems (convection-diffusion) using finite volume method.
5. Possess the knowledge of algorithm for pressure-velocity coupling for incompressible flow using SIMPLE, SIMPLER, SIMPLEC, PISO and etc.
6. Analyze and suggest the type of turbulence models to be chosen for IC engine subsystems.

Module:1	Governing Equations of Fluid flow and Heat Transfer	4 hours

Impact of CFD on engineering applications, Merits of CFD. Vector calculus, Integral transform theorems, Reynolds transport theorem, substantial derivative. Conservation of mass, momentum and energy equations in conservation and non-conservation forms. Physical boundary conditions.

Module:2	Mathematical Nature of the Governing Equations and discretization methods	6 hours

Characteristics of PDE - elliptic, parabolic and hyperbolic types of PDE, well-posed problems. Basic aspects of discretization, Different discretization techniques – Introduction to finite difference, finite volume, finite element and spectral methods.

Module:3	Finite difference method	8 hours

Finite difference discretization (FDM), Taylor series method, difference operator method, Forward, backward and central differences, Explicit, Implicit and semi-implicit approaches. Finite difference solution to steady and unsteady 1-D and 2-D diffusion problems. Different types of errors - consistency, accuracy, and stability.

Module:4	Finite volume method	8 hours

Central difference, upwind, quick, exponential, hybrid and power law schemes- False diffusion. Finite volume solution to 1-D and 2-D convection-diffusion problems.

Module:5	Solution Algorithm for Pressure-velocity Coupling	6 hours

Staggered grid, The pressure velocity corrections, The pressure correction equation, SIMPLE, SIMPLER, SIMPLEC, PISO algorithms.

Module:6	**Turbulence Modelling**	**8 hours**
Nature, Description and Characterization of turbulent flow, Reynolds averaging, Reynolds averaged N-S equations, Eddy viscosity hypothesis, Reynolds Stress Transport Equations. First order closures: k-ε two equation models, SST k-ω model. Large Eddy Simulations**.**		
Module:7	**Application of CFD in IC engines**	**3 hours**
Flow through manifolds, valves and ports, Elements of air motion in engines. Outline of fluid dynamic models, application of available commercial codes to engine processes with and without chemical reactions.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	John D. Anderson, JR., Computational Fluid Dynamics the Basics with Applications, McGraw Hill Education, Fifth reprint, Indian Edition, 2017.
2	Joel H. Ferziger, Milovan Perić, and Robert L. Street., Computational Methods for Fluid Dynamics, Springer, 4th edition, 2020.
Reference Books	
1	K. Muralidhar, and T. Sundarajan, Computational Fluid Flow and Heat Transfer, second edition (reprint), Narosa Publishing House, New Delhi, 2014.
2	H.K Versteeg and W Malalasekera, Introduction to Computational Fluid Dynamics, An: The Finite Volume Method, second edition, Prentice Hall India, 2010.
Mode of Evaluation: CAT, Written assignment, Quiz and FAT	

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE611L	Vehicle Safety and Lighting	3	0	0	3
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To introduce vehicle passive and active safety systems.
2. To broaden the understanding crash testing and lighting.
3. To gain the basic knowledge of lighting of automotive vehicles.
4. To broaden the importance of vehicle safety and lighting.
5. To enable the students to apply the knowledge modern vehicle systems.

Course Outcome

Upon Successful Completion of this course , Students will be able to

1. Impart knowledge about safety and vehicle structural crashworthiness
2. Design the human response to impact response system
3. Analyze the performances of vehicle safety systems and lighting
4. Familiarize the modern lighting system
5. Develop the modern vehicle safety and lighting systems

Module:1	Introduction to safety and Vehicle structural crashworthiness	6 hours

Automotive Safety-Active and passive safety, Driver assistance systems in automobiles Definitions and terminology. Balance of stiffness and toughness characteristics and energy absorption characteristics of vehicle structures, Design of crash crumple zones, Modeling and simulation studies, Optimization of vehicle structures for crash worthiness.

Module:2	Crash testing	7 hours

Types of impacts, and Impact with rebound, movable barrier tests, Analysis and simulation of vehicle in barrier impacts, Roll over crash tests, Behavior of specific body structures in crash testing, Photographic analysis of impact tests, Regulatory requirements for crash testing. Side and Frontal Pole Impact, Pedestrian Impact.

Module:3	Ergonomics and Human response to Impact	7 hours

Importance of Ergonomics in Automotive safety, Locations of controls, Anthropomerty, Human impact tolerance, Determination of Injury thresholds, Severity Index, Study of comparative tolerance, Application of Trauma for analysis of crash injuries. Injury criteria‘s and relation with crash and modeling and simulation studies in dummy.

Module:4	Vehicle safety systems	6 hours

Survival space requirements, Restraints systems used automobiles, Types of safety belts, Head restraints, Air bags used in automobiles, Use of energy absorbing systems in automobiles, Impact protection from steering controls, Design of seats for safety, types of seats used in automobiles. Importance of Bumpers in automobiles, Damageability criteria in bumper designs. Introduction to the types of safety glass and their requirements and rearward field of vision in automobiles, Types of rear view mirrors and their assessment. Warning devices, Hinges and latches etc.

Module:5	Fundamentals of light, vision and colour	7 hours

Electromagnetic radiation and light, Propagation of light, Spectral sensitivity of light, Measures of radiation and light, Standard elements for optical control. Illuminant calculations, Derivation of luminous flux from luminous intensity, flux transfer and inter reflection, luminance calculations, discomfort glare, eyes as an optical system, visual processing, lighting for results, modes of appearance, Pointers for lighting devices. Nature of the colour, Tri-chromatic Colorimetry, Surface colour, colour spaces and colour solids,, colour rendering.

Module:6	**Light Measurements, Testing equipment calibration and photometric practice**	**6 hours**
Basics of standards and detectors, spectral measurements and Colorimetry, illuminant meters and luminance meters, colorimeters. Fundamentals of equipment used for light measurement in Automotive field; Gonio - Photometer, Reflecto-meter, Colorimeter, Integrating sphere, types, application, coordinates system, Types of sensors and working principle, construction, characteristics etc. used in different equipment. National and international Regulations, test requirements and testing procedure.		
Module:7	**New Technology in Automotive lighting**	**4 hours**
Technology progress in automotive lighting, Gas Discharges lamps, LED, adoptive front lighting system, Daylight running lamps		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Jullian Happian-Smith 'An Introduction to Modern Vehicle Design' Butterworth – Heinemann , ISBN 07506 5044 3. 2002
2.	Burkard Wördenweber · Jörg Wallaschek · Peter Boyce · Donald Hoffman, 'Automotive Lighting and Human Vision' ISBN 978-3-540-36696-6 Springer Berlin Heidelberg New York. 2007
Reference Books	
1.	Ulrich Seiffert and Lothar Wech, "Automotive safety handbook", SAE International , SAE ISBN 978-0-7680-1798-4 , 2007
2.	Paul Du Bois et al., "Vehicle Crashworthiness and Occupant Protection", American Iron and Steel Institute, Southfield, Michigan 48075, 2004
3.	Watts, A. J., et al "Low speed Automobile Accidents" Lawyers and Judges 2003**.**
4.	Edward .A, "Lamps and Lighting", Hodder & Stoughton, London, 1993.
Mode of Evaluation: CAT, Written assignment, Quiz and FAT	

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM504L	Finite Element Methods	3	0	0	3
Pre-requisite	Nil	Syllabus Version			
		1.0			

Course Objectives :

The main objectives of this course are to:

1. Enable the students understand the mathematical and physical principles underlying the Finite Element Method (FEM) as applied to solid mechanics and thermal analysis
2. Introduce students to the theory of elasticity
3. Teach students the characteristics of various elements in structural and thermal analysis and selection of suitable elements for the problems being solved
4. Introduce students to various field problems and the discretization of the problem
5. Make the students derive finite element equations for simple and complex elements

Course Outcome :

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

1. Apply the knowledge of mathematics and engineering to solve problems in structural and thermal engineering by approximate and numerical methods
2. Employ various formulation methods in FEM.
3. Apply suitable boundary conditions to a global equation for bars, trusses to solve displacements, stress and strains induced.
4. Apply suitable boundary conditions to a global equation for beams and frames to solve displacements, stress and strains induced.
5. Analyze linear 2D and 3D structural problems using CST element and analyze the Axi-symmetric problems with triangular elements. Evaluate heat transfer problems for bar, stepped bar and fin like structures.
6. Analyze the Vector Variable problems using Plane stress, Plane Strain and Axi-symmetric conditions
7. Demonstrate the use of Finite element analysis in Production Processes

Module:1	Fundamental concepts	6 hours

Physical problems, Finite Element Analysis as Integral part of Computer Aided Design;. Stresses and Equilibrium; Boundary Conditions; Strain-Displacement Relations; Stress – strain relations, Linear and nonlinear material laws; Temperature Effects; Definition of Tensors and indicial notations; Deformation gradients; Classification of different types of deformations; Degree of Freedom; Field Problem and their degree of freedom. Solid Mechanics Problems and Fluid Mechanics Problems. Deformations and stresses in bars, thin beams, thick beams, plane strain- plane stress hypothesis, thin plate, thick plate, axisymmetric bodies; Approximate nature of most of these deformation hypotheses; General 3D deformation (linear small deformation), Large deformation (nonlinear).

Module:2	General Techniques and Tools of Displacement Based Finite Element Analysis	6 hours

Mathematical models, Approximate solutions, Minimization procedure, Variational procedure, Interpolation polynomial method, Nodal approximation method and Finite Element Solutions. Strong or classical form of the problem and weak or Variational form of the problem; Galerkin's and Weighted residual approaches; Shape and interpolation functions for 1D, 2D & 3D applications; Use of shape (interpolation) functions to represent

general displacement functions and in establishment of coordinate and geometrical transformations; Hermite, Lagrange and other interpolation functions.		
Module:3	**One Dimensional Problems: Bars & Trusses**	**6 hours**
Introduction; Local and global coordinate systems; Transformation of vectors in two and three dimensional spaces; Finite Element stiffness matrix and load vector of a basic element in local coordinate system using energy approach; Assembly of Global Stiffness Matrix and Load vector; Treatment of boundary conditions; Solution algorithms of linear system matrices; Example problems in trusses; Formulation of dynamics analysis, global mass matrix; Extraction of modal frequencies and mode shape.		
Module:4	**One Dimensional Problems – Beams and Frames**	**7 hours**
Finite Element Modeling of a basic beam element in local coordinate system using energy approach; Formulation of element matrices; Assembly of the Global Stiffness Matrix, Mass matrix and Load vector; Treatment of boundary Conditions; Euler Bernoulli (thin) beam element and Timoshenko (thick) beam element; Beam element arbitrarily oriented in plane (2D) as Plane frames and in space as space frame analysis (3D); Solution algorithms of linear systems.; extraction of modal frequencies and mode shape.		
Module:5	**Two Dimensional Analysis – Scalar Variable Problems**	**6 hours**
Formulation of 2D problems using Partial Differential Equations; Solution algorithm using Energy principle; Constant Strain Triangles (CST); Bilinear Quadrilateral Q4; Formulating the element matrices; Modelling boundary conditions; Solving the field problems such as heat transfer in automotive cooling fin, engine cover; Torsion of a non-circular shaft etc.		
Module:6	**Vector Variable problems - Plane stress, Plane Strain and Axi-symmetric Analysis**	**6 hours**
Equilibrium equation formulation – Energy principle and formulating the element matrices - Plane stress, plane strain and axi-symmetric elements; Orthotropic materials; Isoparametric Elements; Natural co-ordinate system; Higher Order Elements; Four-node Quadrilateral for Axisymmetric Problems; Hexahedral and tetrahedral solid elements; Linear, Quadratic and cubic elements in 1D, 2D and 3D; Numerical integration of functions; Gauss and other integration schemes. C0 and C1 continuity elements.		
Module:7	**Analysis of Production Processes**	**6 hours**
FE Analysis of metal casting – Special considerations, latent heat incorporation, gap element – time stepping procedures – Crank – Nicholson algorithm – Prediction of grain structure - Basic concepts of plasticity – Solid and flow formulation – small incremental deformation formulation – FE Analysis of metal cutting, chip separation criteria, incorporation of strain rate dependency.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Seshu.P, Finite Element Analysis, Prentice Hall of India, 2013
2.	Saeed Moaveni, Finite Element Analysis, Theory and Application with ANSYS, Pearson Fifth Edition, 2021

Reference Books			
1	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt,Concepts and Applications of Finite Element Analysis, John Wiley & Sons, Incl.2002.		
2	S.S.Rao, Finite element method in Engineering, 2011, Butterworth Heinemann		
3	J.N Reddy, An introduction to the Finite Element Method, 2017, Mcgraw Hill		
4	Tirupathi R. Chandrapatla, Ashok D. Belegundu, Introduction to Finite Element in Engineering Pearson 4th Edition, 2011		
Mode of Evaluation**:** CAT, Written assignment, Quiz and FAT			
Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCDM504P	Finite Element Methods Lab	0	0	2	1
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. To enable the student's skills in FEM software that can be used and implemented for various engineering applications.
2. To develop proficiency in the application of the finite element method (modeling, analysis, and interpretation of results) to realistic engineering problems

Course Outcome

1. Demonstrate the ability to create and analyze the FE models for trusses, frames, plate structures, machine parts, and engineering components using general-purpose FE softwares like Ansys, Matlab etc
2. Demonstrate the ability to evaluate and interpret FEA analysis results for design and evaluation purposes

Indicative Experiments

1.	Stress analysis of a bar without considering self-weight	4 hours
2.	Effect of self-weight on stress of a vertical hanging bar	4 hours
3.	Stress analysis of the tapered rod	4 hours
4.	Two dimensional truss problem	4 hours
5.	Bending moment and shear force diagram of various beams	4 hours
6.	Plane stress and plane strain analysis	4 hours
7.	Modal, harmonic and transient analysis on bar, beam and plates	3 hours
8.	Axi-symmetric analysis	3 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment: CAT, Written assignment, Quiz and FAT

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE696J	Study Oriented Project				02
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

Course Outcome:

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

Module Content	(Project duration: One semester)

This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE697J	Design Project				02
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

1. Students will be able to design a prototype or process or experiments.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

Course Outcome:

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model or process or experiments.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

Module Content **(Project duration: One semester)**

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

Mode of Evaluation: Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE698J	**Internship I/ Dissertation I**				**10**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

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

Course Outcome:

1. Considerably more in-depth knowledge of the major subject/field of study, including deeper insight into current research and development work.
2. The capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.
3. A consciousness of the ethical aspects of research and development work.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Module Content	**(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

Recommended by Board of Studies	27-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MAUE699J	**Internship II/ Dissertation II**				**12**
Pre-requisite	**NIL**	**Syllabus version**			
		1.0			

Course Objectives:

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

Course Outcome:

Upon successful completion of this course students will be able to

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

Module Content **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
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