VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

(VJTI)

MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum

(Scheme of Instruction & Evaluation and Course contents)

For

Two Year Postgraduate Programme

Leading to Master of Technology

(M Tech) Degree in

Mechanical Engineering with specialization in Automobile Engineering

Implemented from the batch admitted in Academic Year 2022-23

Mechanical Engineering with specialization in Automobile Engineering

Program Outcomes (POs)

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

PO2: An ability to write and present a substantial technical report/document in the area of Automobile Engineering.

PO3: Students should be able to demonstrate a degree of mastery in the area of Automobile Engineering. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

V J T I Veermata Jijabai Technological Institute
(Central Technological Institute, Maharashtra State, INDIA)
H. R. Mahajani Marg, Matunga, Mumbai 400019
Tel.No. +91 22 24198101-02 Fax +91 22 24102874
www.vjti.ac.in

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(Scheme of Instruction & Evaluation and Course contents)

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(M Tech)

In

Mechanical Engineering (with Specialization in Automobile Engineering)

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M.Tech. in Mechanical Engineering (with specialization in Automobile Engineering)

Scheme of Instruction and Evaluation

SEMESTER I

Scheme of Instruction					Scheme of Evaluation			
Sr. No	Course Code	Course Title	L-T-P	Credits	TA	MST	ESE	ESE hours
1.	MEAE5001S	Computational Methods	3-0-0	3	20	20	60	3
2.	MEAE5011T	Vehicle Body Engineering	3-1-0	4	20	20	60	3
3.	MEAE5012S	Prime Movers for Automobiles	3-0-0	3	20	20	60	3
4.		Programme elective 1	3-1-0	4	20	20	60	3
5.		Programme elective 2	3-0-0	3	20	20	60	3
6.		Open elective 1	3-0-0	3	20	20	60	3
7.	MEAE5071L	Laboratory 1- Computational Methods Lab	0-0-2	1	60%CIE		40	-
8.	MEAE5072L	Laboratory 2 - Advanced Automobile Transmission System	0-0-2	1	60%CIE		40	-
9.	MEAE5073L	Laboratory 3 - Automotive Engines Laboratory	0-0-2	1	60%CIE		40	-
10.		Liberal Learning	0-0-2	1	100%CIE		-	-
			28	24				

abbreviations **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **CIE** Continuous In-semester Evaluation

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SEMESTER II

Scheme of Instruction					Scheme of Evaluation			
Sr. No	Course Code	Course Title	L-T-P	Credits	TA	MST	ESE	ESE hours
1.	MEAE5002S	Research Methodology and IPR	3-0-0	3	20	20	60	3
2.	MEAE5013T	Vehicle Dynamics	3-1-0	4	20	20	60	3
3.	MEAE5014S	Hybrid Electric Vehicles	3-0-0	3	20	20	60	3
4.		Programme elective 3	3-1-0	4	20	20	60	3
5.		Programme elective 4	3-0-0	3	20	20	60	3
6.		Open elective 2	3-0-0	3	20	20	60	3
7.	MEAE5074L	Laboratory 4 – Advanced Finite Element Analysis	0-0-2	1	60%CIE		40	-
8.	MEAE5075L	Laboratory 5 - Computational Fluid Dynamics	0-0-2	1	60%CIE		40	-
9.	MEAE5076L	Laboratory 6 - Automotive System & Composite Materials Laboratory	0-0-2	1	60%CIE		40	-
10.		Liberal Learning	0-0-2	1	100%CIE		-	-
			28	24				

abbreviations **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **CIE** Continuous In-semester Evaluation

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List of Programme Elective 1

Sr. No.	Course Code	Course Title
1	MEAE5021T	Advanced Automobile Transmission System
2	MEAE5022T	Advanced Thermodynamics and Combustion
3	MEAE5023T	Machine Dynamics and Vibrations

List of Programme Elective 2

Sr. No.	Course Code	Course Name
1	MEAE5031S	Characterization of Engineering Materials
2	MEAE5032S	Advanced Heat Transfer
3	MEAE5033S	Automotive Electronics

List of Programme Elective 3

Sr. No.	Course Code	Course Name
1	MEAE5041T	Advanced Finite Element Analysis
2	MEAE5042T	Design of Suspension System
3	MEAE5043T	Automotive Noise vibration and Harshness

List of Programme Elective 4

Sr. No.	Course Code	Course Name
1	MEAE5051S	Computational Fluid Dynamics
2	MEAE5052S	Automotive Aerodynamics
3	MEAE5053S	Automotive Electricals and Battery Management

List of Open Elective 1

Sr. No.	Course Code	Course Title
1	MEAE5061S	Automotive Safety & Crashworthiness

List of Open Elective 2

Sr. No.	Course Code	Course Title
1	MEAE5062S	Future Vehicles and Green Technologies

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SEMESTER III

Scheme of Instruction					Scheme of Evaluation
Sr. No	Course Code	Course Title	L-T-P	Credits	
1.	MEAE5091D	Skill Based Course (Project Stage -I)	---	5	100% CIE
2.	MEAE5092D	Skill Based Course (Project Stage -II)	---	5	100% CIE
3.		Self Learning Course - 1	1-0-0	1	100% ESE of 3 hours or credit transfer
4.		Self Learning Course - 2	1-0-0	1	100% ESE of 3 hours or credit transfer
5.		Mandatory Non Credit Course	2-0-0	0	100% ESE of 3 hours or credit transfer
				12	

SEMESTER IV

Scheme of Instruction					Scheme of Evaluation
S. No	Course Code	Course Title	L-T-P	Credits	
1.	MEAE5093D	Skill Based Course (Project Stage -III)	---	5	100% CIE
2.	MEAE5094D	Skill Based Course (Project Stage -IV)	---	7	100% CIE
				12	

SEMESTER-I

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in Automobile Engineering***
Course Code	**MEAE5001S**
Course Title	**Computational Methods**

Course Outcomes

After completion of course, students would be able to

1. Solve algebraic equations, Eigen value problems
2. Analyze data using interpolation and regression methods.
3. Solve ordinary and partial differential equations using numerical techniques

Course Contents

Introduction

Engineering problems and computational methods; Introduction to numerical methods and analysis.

Error Analysis

Approximations; Round-off and Truncation errors; Backward and Forward error analysis

Roots of Nonlinear Equations

Bisection method, Regula Falsi, Secant method, Fixed point Method; Newton-Raphson method; Multiple roots; Roots of system of non-linear equations; Analysis and order of convergence; Polynomials Mueller's method, Bairstow's method**.**

Solution of System of Linear Equations

Direct methods (Gauss Elimination, Gauss-Jordan, LU decomposition, Thomas Algorithm); Perturbation analyses of direct methods matrix and vector norms, condition number of matrix; Iterative methods (Jacobi and Gauss-Seidel); convergence criteria for Jacobi and Gauss Seidel iterative methods, rate of convergence of iterative methods. Successive over Relaxation.

Solution of System of Nonlinear Equations

Iterative methods, Fixed Point iteration, Newton-Raphson method.

Approximation of functions

Approximation using polynomials (Simple, least squares estimation, orthogonal basis functions, Tchebycheff and Legendre polynomials); Interpolation (Newton's divided difference and Lagrange interpolating polynomials, Spline interpolation); Regression

Eigen values and Eigen vectors

Power, inverse power, and inverse power method with shift, Fadeev-Leverrier method for the formulation of the Characteristic polynomials and QR decomposition

Numerical Differentiation

Introduction to finite difference approximations, Derivation of generalized finite difference approximation of any order and accuracy, truncation error analysis, Richardson's extrapolation

Numerical Integration

Newton-Cotes integration formula, Romberg integration and Gauss Legendre quadrature; Ordinary

Ordinary Differential Equations (Initial Value Problems)

Euler's method, Multi-step methods, Runge-Kutta methods, Predictor Corrector Methods. Stiff ODEs. System of IVPs, Stiff problems and Gear's method

Ordinary Differential Equations (Boundary Value Problems)
Decomposition into Linear System of ODEs, Shooting and direct methods;
Partial Differential Equations Introduction to solution of PDEs, Parabolic (diffusion equation and advective-diffusion equation), Elliptic (Laplace equation) and Hyperbolic (Wave equation) equations; Explicit and Implicit Methods, Crank Nicholson Method

Recommended Reading

1. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, McGraw Hill
2. Santosh Gupta, Numerical Methods for Engineers, New age international publishers
3. J.B. Doshi, Differential Equations for Scientists and Engineers, Narosa, 2010
4. Kreyszig, Erwin, I.S., Advanced Engineering Mathematics, Wiley, 1999
5. C. F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education Asia, New Delhi, Sixth Edition, 2006.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5011T**
Course Title	**Vehicle Body Engineering**

Course Outcomes:

The student should be able to –

1. Evaluate various analytical techniques for vehicle body engineering.
2. Design different frames types, to minimize the deformation in the body.
3. Analyze the effects of vibration, noise and ergonomics of the vehicle.
4. Evaluate various methods in vehicle body manufacturing

Course Contents

Introduction to vehicle body engineering and various systems mounted on frames: Vehicle body type and layouts, load distribution, dynamic loading, Aerodynamic drag on cars and commercial vehicle, drag reduction chassis frames for commercial vehicles, analysis of frame structure and application to chassis frames.

Body Types and constructions: Integral construction for cars, structural analysis integral chassis, application of theory of plates, shell to body components, principles of thin walled beams. Shear centers.

Noise control: Noise and vibration sources, Effects of vibration on various components of vehicle and comfort of passengers. Engine, body panel, tyre and vibration damping and absorption.

Safety consideration: impact protecting desirable crash characteristics. CMV(Central Govt. Motor Vehicle acts) rules and regulations.

Vehicle Ergonomics: driver visibility and passenger seating and controlling arrangements for more safety.

Recommended Reading

1. Reimpell J.,―The automotive chassis: Engineering principle, 2ndEdition, 1983
2. Vehicle Body Engineering, Powloski J, Business Books Ltd, 2000.
3. Automotive Body, Volume-I (component design), Lorenzo Morello, Springer, 2013
4. Automotive Engineering (Power Train, Chassis system and Vehicle Body), David A Crolla, Elsevier collection, 2009.

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in Automobile Engineering***
Course Code	**MEAE5012S**
Course Title	**Prime Movers for Automobiles**

Course Outcomes:

The student should be able –

1. Examine the effect of engine variables on the combustion processin S.I. and C.I. engines.
2. Analyze the performance of naturally aspirated and supercharged internal combustion engines.
3. Compare the performance of various sub systems employed in theengines.
4. Evaluate the data of engine emissions and suggest solutions.

Course Contents

Introduction to IC engines

Classification of Prime Movers; IC Engines as Prime Movers; Historical Perspective of IC Engines, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Differences between 2-stroke and 4-stroke cycle engines, Differences between SI and CI engines.

Combustion in SI and CI Engines

SI Engines: Brief treatment on Flame Propagation- Combustion phenomena (Normal and Abnormal), Factors affecting, Detonation, Ignition quality(Octane rating), Requirements of good combustion Chamber-Types, HUCR; CI

Engines

Importance of air motion and Compression Ratio, Mixture Preparation inside the CC. Normal and abnormal combustion - Ignition Quality (Cetane rating); Characteristics of a Good Combustion Chamber- Classification of Combustion Chambers (DI and IDI).

Fuel Metering in SI and CI Engines

Brief treatment on Carburetion and fuel injection systems for SI Engines; Types of Fuel injection Systems- Individual, Unit and Common Rail (CRDI), Fuel Injectors-Nozzle types, Electronic Control Unit (ECU)-Numerical problems on fuel injection.

Supercharging of IC Engines

Need of Supercharging and advantages, Configurations of Supercharging-Numerical problems on turbocharging.

Pollutant emissions from IC Engines

Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen (NO-NOX) and Particulate Matter. Mechanism of formation of pollutants, Factors affecting pollutant formation. Emission norms-EURO and Bharat stage norms.

Performance of IC Engines

Classification of engine performance parameters- Measurement of brake power, indicated power and friction power. Engine and Chassis dynamometers, driving cycles, Factors affecting performance,

Heat loss, Air-fuel ratio, Energy Balance.

Advances in IC Engines

New combustion concepts- Stratified Charge Engines, HCCI, PCCI and RCCI. New injection concepts-port fuel injection and gasoline direct injection systems.

Introduction to IC engines: Classification of Prime Movers; IC Engines as Prime Movers; Historical Perspective of IC Engines, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Differences between 2-stroke and 4-stroke cycle engines, Differences between SI and CI engines.

Recommended Reading

1. Internal Combustion Engine Fundamentals, John.B. Heywood, McGraw Hill Co.2018, II Edition.
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, CRC Press, 2018, II Edition.
3. Engineering Fundamentals of IC Engine, W.W. Pulkrabek , PHI Pvt.Ltd 2002 II Edition
4. Electric vehicle technology explained, John Lowry and James Larmine, John Wiley and Sons, 2012.
5 PEM Fuel Cells-Theory and Practice, Frano Barbir, Elsevier Academic Press, 2005.

Programme Elective-I

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5021T**
Course Title	**Advanced Automobile Transmission System**

Course Outcomes:

Students should be able to -

1. Interpret the performance characteristics of various transmission components.
2. Evaluate various requirements and components of semi - automatic & automatic transmission systems.
3. Analyze the performance of various lubricants and bearings

Course Contents

Basic transmission principles

Introduction, Geared Transmissions, Hydraulic Drives, Electric Transmissions, Miscellaneous Mechanical Drives.

Design requirement of automatic transmissions

Starting Duty, Power Transmission Requirements, Range Of Transmission Ratios, Control Mechanism, Drivers Override.

The development of mechanical gearbox

Sliding Gears, Constant Mesh Gears, Synchromesh Gearboxes, Full Torque And Automatic Gear Changes.

Semi-automatic transmissions

A Simplified Specifications, Automatic Clutches, Simplified Gear Changes.

Epicyclic gear trains

General Considerations, Advantages, Simple Epicyclic Gear, Automobile Epicyclic Gear, Compound Epicyclic Gear, Epicyclic Transmissions, Epicyclic Gear Ratios.

Automatic clutches and couplings

Centrifugal Clutch, Saxomat Automatic Clutch, Magnetic Clutch, Magnetic Fluid Clutch, Electromagnet Armature Clutch, Gravina Clutch, Fluid Couplings, Operation And Modification Of Fluid Couplings, Advantages And Types Of Fluid Couplings.

The torque convertor

Introduction, Terms , Combined Convertor And Coupling Unit, Convertor With Two Turbine Members , Convertor With Three Turbine Members, Convertor With Three Stator Members, Automobile Torque Convertor Arrangements, Blade Angles And Fluid Flow, Simple And Variable Blade Angles, Convertor Fluids, Cooling, Stall Speed, Towing.

Automotive bearing Applications

Front Wheel Bearings, Rear Wheel Bearings, Integral Wheel Bearings, Integral Water pump Bearings, Differential Bearings, Transmission Bearings.

Lubricants

Selection for General Application And Special Application Such As High Temperature Low Temperature, Extreme Pressure.

Recommended Reading:

1. Andras Z. Szeri, - Fluid film lubrication theory and design‖,2 nd Edition, 1992.
2. J.G. Giles - Automatic and fluid transmissions‖,1 st Edition1969.

3. Arthur w. Judge - Modern transmission systems‖,1 st Edition, 1973.
4. Robert P. Tata-Automotive Bearing Applications, 2012.
5. Rohner - Industrial hydraulics‖,2nd Edition, 1969.
6. John Pippenger - Industrial hydraulics‖,1 st Edition, 1969.

Research Assignment:

Each team of 4-5 students will submit a case study of a transmission system of their choice. The research assignment will constitute collection of literature, model of the system, functional description of the components involved. Finally, each team has to submit a detailed report along with a presentation.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5022T**
Course Title	**Advanced Thermodynamics and Combustion**

Course Outcomes-

The student should be able to -

1. Apply the Laws of Thermodynamics to different systems.
2. Apply Entropy Principle to various heat flow systems.
3. Evaluate thermodynamic system using classical and Statistical thermodynamics.
4. Apply the Principles of Combustion Thermodynamics.

Course Contents

Laws of Thermodynamics:

Zeroth and First Law of Thermodynamics applied to macroscopic systems.

Second Law analysis applied to macroscopic systems.

Concept & Evaluation of entropy, Clausius inequality, Principle of increase of entropy.

Maxwell equations, Helmholtz's & Gibbs's energy functions.

Entropy, Exergy and Availability for Single & Multiphase Systems :

Available energy, Availability, Exergy & Irreversibility of a closed system in steady flow and their applications in Thermal Engineering.

Real gases and their equations of state, Thermodynamic relations for a single component single phase systems.

Generalized charts for compressibility, enthalpy changes and fugacity, mixtures of real gases; ideal and non-ideal liquid solutions.

Statistical Thermodynamics

Fundamental concepts of statistical thermodynamics.

Thermodynamic properties and kinetics of perfect monatomic gases.

Maxwell –Boltzmann, Fermi-Dirac and Bose – Einstein statistics.

Combustion Thermodynamics

Combustion Thermodynamics and Thermochemistry, Heat of Reaction, Calorific Value, Adiabatic Flame Temp, Combustion Kinetics.

Combustion Modeling: Gas, Liquid and Solid Combustion.

Recommended Reading:

1. Richard E. Sonntag and Claus Borgnakke, Fundamentals of Thermodynamics, John Wiley & Sons, New York, 2009.
2. Michael J. Moran, Howard N. Shapiro, Fundamentals of Engineering Thermodynamics, Wiley International, 2014.
3. Chang L. Tien and J. H. Lienhard, Statistical Thermodynamics, McGraw Hill Book Company, New York, 1979.
4. Stephen Turns, An Introduction to Combustion: Concepts and Applications, McGraw-Hill,

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5023T**
Course Title	**Machine Dynamics and Vibration**

Course Outcomes:

Students should be able to -

1. Solve real life problems using 3D vector mechanics.
2. Formulate mathematical model of vibratory system under giveninput conditions.
3. Estimate response of the system.
4. Evaluate response of the system

Course Contents:

Machine Dynamics

Kinematics of Rigid bodies:

First and Second time derivatives of a vector fixed in moving reference frame – velocity and acceleration of a point on rigid body – moving on rigid body. Relationship of time derivatives of vector for different reference frames, Coriolis force.

Inertia tensor:

Definition of inertia quantities, Translation of coordinate axes, transformation properties of inertia terms, Tensor notations of transformation, Ellipsoid of inertia, Principal moment of inertia.

Dynamics of Rigid Bodies:

Angular momentum and its time derivative for a particle and system of particles. Euler's Equation of motion, Applications of Euler's equation, Fixed point rotation.

Mechanical Vibration

Single degree of freedom:

Un-damped & Damped vibration, forced vibration. Multi-degree of freedom: Free vibration, modes & mode shape, nodes, Exact and approximate solution methods. Lagrange equation for problem formulation. Two degree of freedom system – co- ordinate coupling - solution.

Vibration under general force conditions:

Response under periodic and Non periodic force, Solution using Laplace and Fourier transform, Numerical Methods.

Vibration of continues systems:

Transverse vibration of cable, Longitudinal vibration of bar/rod, Lateral vibration of Beam, Torsion vibration of shaft Rayleigh's method; Rayleigh Ritz method.

Vibration control:

Balancing of reciprocating and rotating masses, controlling natural frequencies, vibration isolation, vibration absorber

Vibration Measurement and applications:

Vibration measuring instruments, Exciters/shakers, Signal analysis, Experimental modal analysis

Introduction to non-linear vibration.

Recommended Reading

1. S. S. Rao, ―Mechanical Vibration‖, 5th Ed, 2004.
2. I. H. Shames, ―Engineering Mechanics Statics &Dynamics‖, 4th Ed.
3. Srinivasan, ―Non-Linear mechanical vibration‖, 1stEdition, 1996.
4. S. Graham Kelly, ―Fundamentals of Mechanical vibration‖, 3rd Edition, McGraw Hill Book Company.
5. Thomas Kane, ―Dynamics – Theory and Applications‖, 1st Edition, McGraw Hill Book Company.

Programme Elective-II

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5031T**
Course Title	**Characterization of Engineering Materials**

Course Outcomes

The student should be able to

1. Identify advanced techniques available for characterization of materials.
2. Select a characterization technique to evaluate the behavior of materials
3. Analyze defects and failure surfaces of materials
4. Analyze the characterization results by various equipment

Course Contents

Introduction

Overview of the course; materials classification and their properties, Importance of materials selection, property classification, Criteria for selection of materials, Ashby charts for materials selection, Engineering Design process and the role of materials; material property charts; selection of materials based on function, objective, constraints and free variables; examples of material selection for typical applications.

Computer aided materials selection

Selection of process based on material classification; pencil curve approach; material selection for multiple constraints and multiple objective cases; multiple constraints and conflicting objectives. Co-selection of material and shape; concept of macroscopic and microscopic shape factors; Four quadrant method of material selection. General Properties of plastics, polymers and elastomers; visco-elastic properties; short-term and long-term properties of plastics.

High temperature materials

Families of super alloys and their characteristics; creep and fatigue resistance of super alloys; role of precipitates in strengthening of super alloys; repair of super alloys after creep damage; coatings for high temperature materials.

Fundamentals of ceramics

General properties, applications of ceramics for critical applications. Design considerations. Surface treatment of materials using coatings; type of coatings; PVD and CVD coatings. Basics of electro-plating and electro-less plating.

Physical characterization of materials

Optical Microscopy, SEM,TEM, Density, Void content in materials, Electron Probe Micro Analyzer (EPMA), Atomic Force Microscopy (AFM), Thermogravimetric analysis (TGA), nano indentation, NMR spectroscopy, EDAX, FTIR, XRD.

Mechanical characterization

Tensile test, flexural test, compression test, ILSS, creep, fatigue, Hardness, Impact test, Fracture toughness test, Principle, construction and operation working parameters, equipment operation. selection of plastics based on mechanical properties, degradation due to environment, of laminates.

Recommended Reading

1. M.F. Ashby, Materials Selection in Mechanical Design, Butterworth Heinemann, 4th Edition, 2010
2. Yang Leng, Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, 2008
3. ASM Handbook Materials Characterization, ASM International, 2008.
4. V. T. Cherapin and A. K. Mallik, Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.
5. Dieter, George E., Mechanical Metallurgy, McGraw Hill, 2nd Edition, 2005
6. Crawford, R. J., Plastics Engineering, Butterworth-Heinemann, 3rd Edition, 2002.
7. Donachie, M. J. and Donachie, S. J., Super alloys A technical guide, ASM International, 2002.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5032T**
Course Title	**Advanced Heat Transfer**

Course Outcomes:

Students should be able to -

1. Apply numerical techniques to convective heat flow
2. Evaluate radiation heat transfer between black body and gray body surfaces & Gas radiation Apply laws of heat transfer and governing equations to a given thermal system.
3. Employ computational methods for simulation of complex conduction and fin heat transfer
4. Design a thermal device for steady and unsteady state industrial applications.

Course Contents

Review of heat transfer fundamentals, Physical concepts and Governing Equations
Heat conduction equation in differential form, solution methods, steady state, unsteady state problems-fins, moving boundaries.
Steady, One-dimensional heat conduction with and without heat generation – Plane walls & Radial systems.
Review of steady-state (one and two dimensional), transient conduction heat Transfer and solutions of classical heat conduction problems.
Radiation basics, Gas Radiation and Heat pipes
Introduction to radiation Black bodies, Diffuse surface transfer, enclosures, view-factor, radiation shield.
Equation of radiative transfer; absorbing media, Coupled problems – radiation and conduction
Free and forced convection, integral equation, analysis and analogies. Convection with body forces.
Transpiration cooling, ablation heat transfer, Boiling, condensation and two phase flow mass transfer.
Advanced computational and analytical techniques for conduction, convection & radiation.

Recommended Reading

1. Frank P. Incropera and David P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley and Sons, 1981.
2. M. Thirumaleshwar Fundamentals of Heat and Mass Transfer, Pearson Education Publication., 2009
3. F. Mills and V.Ganesan, Heat Transfer, Pearson Education Publication., 2009.
4. Frank Kreith and Mark S. Bohn, Principles of Heat Transfer, Harper and Row Publishers, 1986
5. R. C. Sachdeva Fundamentals of Engineering Heat and Mass Transfer, Wiley Eastern Ltd., INDIA.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5033T**
Course Title	**Automotive Electronics**

Course outcomes:

The students be able to -

1. Understand the electronic circuit fundamentals, safety and basic test equipment.
2. Analyze vehicle electronic circuits.
3. Outline the working of batteries, starting systems, charging systems, ignition systems and auxiliaries.
4. Analyze the performance of sensors and ECU.

Course Contents

Introduction: Overview of the course, Examination and Evaluation patterns, History of Automotive electronics. Circuit fundamentals: voltage, current, resistance, circuits components, series and parallel circuits in vehicles, basic test equipment: voltmeters, ammeters, ohmmeter, Digital Storage Oscilloscope

Electronic fundamentals: Basic principles of semiconductor technology, electronic control input devices, Passive components, Semiconductor components, Manufacture of semiconductor components and circuits

Wiring diagrams and Batteries: Wiring diagram symbols, using the wiring diagram, automotive batteries, diagnosing batteries, servicing batteries.

Electrical and electronic systems in the vehicle:. Motronic-engine management system, Electronic diesel control (EDC), Lighting technology, defogger, horn, and windshield wiper circuits, diagnosing defogger, horn, and windshield wiper circuits, motor driven accessories, diagnosing motor driven accessories, Electronic stability program (ESP), Adaptive cruise control (ACC), Occupant-protection systems, Safe working practices-work cloths, eye protection, fire protection, battery safety.

Starting and charging systems: starting circuits, solenoid shift starters, diagnosing and servicing solenoid shift starters systems, positive engagement starters, diagnosing and servicing positive engagement starting system, gear-reduction starters, diagnosing gear- reduction starters, charging system overview, field circuits, diagnosing and servicing the charging system.

Ignition systems and accessories: Primary and Secondary ignition systems, diagnosing and servicing distributed primary and secondary ignition systems, diagnosing and servicing the secondary ignition system on a distributor-less vehicles, distributor-less ignition primary circuits, diagnosing and servicing the primary circuit on a distributor-less ignition system.

Electronic control units and sensors: Vehicle sensors-speed, Hall phase sensors, temperature sensor, fuel level, battery condition, emissions, feedback circuits,

Micromechanical yaw-rate sensors, Accelerator-pedal sensors, Position sensors for transmission control Steering-angle sensors, Axle sensors.

Cooling of Electronics Equipment: Cooling load of electronics equipment, thermal environment, Electronics cooling in automotive systems, air cooling, liquid cooling, immersioncooling.

Recommended Reading:

1. Automotive Technology, Electricity and Electronics, Al Santini, Cengage Publishers, 2nd Edition, 2011.
2. Bosch Automotive Electrics and Automotive Electronics: Systems and Components, Networking and Hybrid Drive, Robert Bosch GmbH, 5th edition, John Wiley & Sons. Inc. and Bentley Publishers, 2007
3. Understanding Automotive Electronics, William Ribbens, , Elsevier, 2011.

Online Resources:

1. https://www.elprocus.com/

Open Elective-I

Programme Name	**Masters of Technology in Mechanical Engineering with Specialization in Automobile Engineering**
Course Code	**MEAE5061S**
Course Title	**Automotive Safety Crashworthiness**

Course Outcomes:
The students be able to-

1. Identify different safety systems and its role in automobiles
2. Determine vehicle structural crashworthiness
3. Determine injury thresholds and apply trauma for analysis of crash injuries

Course Contents:
Introduction to safety and Vehicle structural crashworthiness & Crash testing: 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, 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.

Ergonomics and Human response to Impact: Importance of Ergonomics in Automotive safety, Locations of controls, Anthropometry, 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 modelling and simulation studies in dummy.

Vehicle safety system: 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, active safety.

Fundamentals of light, vision and colour: 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

New Technology in Automotive lighting: Technology progress in automotive lighting, Gas Discharges lamps, LED, adoptive front lighting system, Daylight running lamps.

Recommended Reading

1. Watts, A. J., et al Low speed Automobile Accidents Lawyers and Judges 1996
2. Jullian Happian-Smith 'An Introduction to Modern Vehicle Design' SAE, 2002
3. Johnson, W., and Mamalis, A.G., Crashworthiness of Vehicles, MEP, London, 1995
4. Edward .A, Lamps and Lighting, Hodder& Stoughton, London, 1993.
5. Keitz H. A. E, Light calculations and Measurements, Macmillan, 1971.

Laboratory Courses

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in Automobile Engineering***
Course Code	**MEAE5071L**
Course Title	**Laboratory-1 Computational Methods Laboratory**

Course Outcomes

After completion of course, students would be able to

1. Write codes that use computational methods to numerically solve problems in a variety of disciplines in Mechanical Engineering.
2. Learn open source packages that implement popular computational methods.
3. Apply the mathematical concepts the Computational Methods course.

Course Contents

The lab will involve development of programs based on numerical methods using Python/Matlab/Scilab etc. for solving variety of common Mechanical Engineering problems.

1. Program for solving system of linear equations
2. Program for regression analysis and curve / function fitting to a given data set
3. Program for root finding on non-linear equation
4. Program for Numerical Differentiation and Integration
5. Program for solving differential equations based on Runge-Kutta formulation
6. Program for Boundary Value Problems in Ordinary and Partial Differential Equations

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5072L**
Course Title	**Laboratory-2 Advanced Automobile Transmission System Lab**

Course Outcomes:

Students should be able to

1. Interpret the performance characteristics of various transmission components.
2. Evaluate various requirements and components of semi-automatic & automatic transmission systems.
3. Modeling and simulation of transmission components

List of Experiments

1. Reliability based design of Automobile Transmission Components
2. Modeling of various transmission components using software CREO/ANSYS
3. Clutch
4. axle
5. torque convertor
6. differential
7. brakes
8. Modeling and simulation of transmission assembly using software Simulation-X

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5073L**
Course Title	**Laboratory-3 Automotive Engines Laboratory**

Course Outcomes:

1. The student should be able –
2. Evaluate the performance of a naturally aspirated I.C.Engine
3. Evaluate the performance of a Supercharged I.C.Engine
4. Compare the subsystems used in I.C. Engines

List of Experiments

1. To dissemble an engine and study the internal details and different sub systems.
2. To perform a Load Test on a CI engine, and evaluate the brake parameters' variation withrespect to load.
3. To perform a Heat Balance on a C.I. Engine, and to analyze the heat flow to varioussystems. To suggest improvements in the performance by reduction of heat losses.
4. To perform a Load Test on an S.I. Engine, and evaluate the brake parameters' variationwith respect to load.
5. To perform a Speed Test on an S.I. Engine and to evaluate its performance with respect to speed.
6. To perform a Morse Test on an S.I. Engine to find out the frictional power and indicatedparameters of the engine, their variation with respect to load and speed.
7. To perform a Load Test on a Turbocharged Engine, to evaluate the performance parameters and to compare all these with the performance of a naturally aspirated engine.
8. Demonstrate of automotive wiring circuits.(level-I Engine)
9. Demonstrate of automotive wiring circuits.(level-II Vehicle)

Recommended Reading

1. Fundamentals of Internal Combustion Engines, H.N.Gupta, PHI publication, 2015.
2. Internal Combustion Engine Fundamentals, J.B. Heywood, McGraw Hill Co.2018
3. Engineering Fundamentals of IC Engine, W.W. Pulkrabek, PHI Pvt.Ltd 2002

SEMESTER-II

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5002S**
Course Title	**Research Methodology and IPR**

Course Outcomes

After completion of course, students would be able to

1. Understand research problem formulation and approaches of investigation of solutions for research problems.
2. Learn ethical practices to be followed in research and apply research methodology in case studies and acquire skills required for presentation of research outcomes
3. Discover importance of Intellectual Property Rights.
4. Promote Intellectual Property Right and patenting.

Course Contents

Research Problem

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

Literature Review

Effective literature studies approaches, analysis, Plagiarism, Research ethics,

Technical Writing

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

Nature of Intellectual Property

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

Patent Rights

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

New Developments in IPR

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

Recommended Reading

1. Ranjit Kumar, Research Methodology A Step by Step Guide for beginners, 2nd Edition
2. C.R. Kothari, Research Methodology Methods and Techniques
3. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd., 2007.
4. Mayall, Industrial Design, McGraw Hill, 1992.
5. Niebel, Product Design, McGraw Hill, 1974.
6. T. Ramappa, Intellectual Property Rights under WTO, S. Chand, 2008

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5013T**
Course Title	**Vehicle Dynamics**

Course Outcomes

Students should be able to-

1. Interpret various forces in static and dynamic conditions.
2. Select analytical modeling for various vehicle dynamics systems.
3. Study vehicle dynamics, their properties, applications & selection of design parameters.
4. Compute effect of various parameters on performance of vehicle systems

Course contents:

Introduction

Terminology-vehicle dynamics, driver, vehicle, load ,environment

Definition's- reference frame, toe-in, toe-out, wheel camber, design position of wheel axis, steering geometry.

Road

Modeling Aspect

DeterministicProfiles-Bump and Potholes, SineWaves

RandomProfiles- Stastical Properties, Classification Of Random Road Profiles, Realizations.

Tire

Introduction- development, composites, forces and torques, measurement, modeling

Contact geometry-basic approach, tire deflection, length contact patch, static contact point, contact point velocity, dynamic rolling radius Forces and torques caused by pressure distribution-wheel load, tipping torque, rolling resistance, Friction forces and torques, First order tire dynamics.

Suspension system

Purpose and Components, Examples, Steering systems, Standard force element, Dynamic force element.

Vertical dynamics

Goals, Basic tuning, Sky hook damper, Non-linear force element.

Longitudinal dynamics

Dynamic wheel load, Maximum acceleration, Driving and braking, Drive and brake pitch.

Lateral dynamics

kinematic approach, steady state cornering, simple handling model.

Driving behavior of single vehicles

Standard driving maneuvers, coach with different loading conditions, different rear axle concept for passenger car.

Recommended Reading:

1. J. R. Ellis, Vehicle Dynamics, Business Books, London, 1st Edition1969
2. Vehicle dynamics-Dr. Georg Rill, 2ND Edition1992.

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in Automobile Engineering***
Course Code	**MEAE5014S**
Course Title	**Hybrid and Electric Vehicles**

Course Outcomes

The student should be able to -

1. Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2. Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
3. Analyze various electric drives suitable for hybrid electric vehicles. Evaluate various methods in vehicle body manufacturing.
4. Analyze the use of different power electronics devices and electrical machines in hybrid electric vehicles.

Course Contents:

Introduction: Sustainable Transportation - Population, Energy, and Transportation - Environment - Economic Growth — Emissions regulations and norms- impact of modern drive- trains on energy supplies-New Fuel Economy Requirement Emergence of Electric Vehicles- Basics of the EV - Constituents of an EV -Vehicle and Propulsion Loads.

HEV Fundamentals: Classification- Hybridization of the Automobile-Mild Hybrids, Full Hybrids, Plug-In Hybrids and Electric Vehicles with Range Extender Hybrids-Architectures of HEVs - Series HEVs Parallel HEVs - Series–Parallel HEVs - Complex HEVs - Diesel and other Hybrids - Other Approaches to Vehicle Hybridization Basics of the HEV-Importance of HEV- Constituents of an HEV –Vehicle Model - Vehicle Performance - HEV Powertrain Component Sizing - Series Hybrid Vehicle - Parallel Hybrid Vehicle - Electrically Peaking Hybrid Concept - Gradeability Requirement - Selection of Gear Ratio from ICE to Wheel - Wheel Slip Dynamics.

Plug-In Hybrid Electric Vehicles: Basics of Plug-In Hybrid Electric Vehicle (PHEV) - Constituents of a PHEV - Comparison of HEV and PHEV - Basics of Fuel Cell Vehicles (FCVs) - Constituents of a FCV-Some Issues Related to Fuel Cells-Introduction to PHEVs - PHEVs and EREVs - Blended PHEVs - Electricity for PHEV Use -PHEV Architectures - Equivalent Electric Range of Blended PHEVs - Fuel Economy of PHEVs - Well-to-Wheel Efficiency - PHEV Fuel Economy - Utility Factor - Power Management of PHEVs - Vehicle-to-Grid Technology(V2G) - PHEV Battery Charging - Impact of G2V - The Concept of V2G- Advantages of V2G - Case Studies of V2G.

Electric Machines and Drives in HEVs: Introduction - Induction Motor Drives - Principle of Induction Motors - Equivalent Circuit of Induction Motor - Speed Control of Induction Machine - Variable Frequency, Variable Voltage Control of Induction Motors -

Efficiency and Losses of Induction Machine - Permanent Magnet Motor Drives - Basic Configuration of PM Motors - Basic Principle and Operation of PM Motors - Unsaturated Motor -Saturated Motor.

Electric Energy Sources and Storage Devices: - Introduction - Characterization of Batteries - Battery Capacity - Energy Stored in a Battery - State of Charge in Battery (SOC) and Measurement of SOC - SOC Determination - Direct Measurement - Amp-hr Based Measurement - Some Better Methods - Initialization Process - Depth of Discharge (DOD)of a Battery - Specific Power and Energy Density - Ampere-Hour (Charge and Discharge) Efficiency - Number of Deep Cycles and Battery Life - Some Practical Issues About Batteries and Battery Life- Battery Management Implementation - Comparison of Energy Storage Technologies.

Fundamentals of Regenerative Braking: Braking Energy Consumed in Urban Driving - Braking Energy versus Vehicle Speed - Braking Energy versus Braking Power
Braking Power versus Vehicle Speed - Braking Energy versus Vehicle Deceleration Rate - Braking Energy on Front and Rear Axles - Brake System of EV, HEV, and FCV.

Special Hybrid Vehicles: Brief Introduction of Hydraulic Hybrid Vehicles - Regenerative Braking in HHVs-Off-Road HEVs - Hybrid Excavators - Hybrid Excavator Design Considerations - Diesel HEVs Electric or Hybrid Ships- Locomotives.

Recommended Reading:

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, CRC Press, 2018, II Edition.
2. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, Chris Mi, M. Abul Masrur John Wiley & Sons, Inc.,2018, II.
3. Electric vehicle technology explained, John Lowry and James Larmine, John Wiley and
4. Sons, 2012.
5. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Hussein, CRC Press, 2003.

Online Resources:

1. Introduction to Hybrid and Electric vehicles by Dr. Praveen Kumar and Prof. S. Majhi (IITGuwahati), NPTEL Course.

(Link: https://nptel.ac.in/courses/108/103/108103009/)

Programme Elective-III

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5041T**
Course Title	**Advanced Finite Element Analysis**

Course Outcomes

At the end of the semester the student should be able to:

1. Formulate numerical model for a given system.
2. Obtain numerical Solutions for boundary value problems.
3. Solve mechanical engineering problems using Finite Element Methods.

Course Contents

Introduction to Finite Element Analysis

Introduction, Basic concept of Finite Element analysis, Discretization of continuum, Stiffness Matrix and Boundary Conditions, Introduction to elasticity, Plane Stress and Plain strain Problem

Finite Element Formulation Techniques

Virtual Work and variational principle, Variational Formulation of Boundary Value problem, Variational Method such as Ritz and weighted Residual methods. Galerkin Method Potential Energy Approach, Displacement Approach

Element Properties

Natural coordinates, Triangular Elements, Rectangular Elements, Lagrange and Serendipity Elements, Solid Elements, Isoparametric Formulation, Stiffness Matrix for Isoparametric Elements, Numerical Integration

Displacement Models

Convergence requirements, Shape functions, Element stresses and strains, Strain-Displacement Matrix for Bar Element, Strain Displacement Matrix for CST Element, Strain Displacement Relation for Beam Element

Analysis of Frame Structure

Introduction of Truss Members, Stiffness of Beam Members, Finite Elements analysis of Beams

FEM for Two Dimensional Solids

Constant and Linear Stain Triangle, Rectangular Elements, Finite Element Formulation for 2D elements. Axisymmetric Elements. Finite Element Formulation of Axisymmetric Elements Heat Transfer by conduction and convection for one dimensional and two-dimensional elements

FEM for Three Dimensional Solids

Tetrahedral elements, Pentahedral (Wedge) elements, Hexahedral (Brick) elements

Error Analysis and Convergence of Finite element Solution

Introduction of error analysis, A Posteriori Error analysis, Super convergent Patch theory.

Dynamic Analysis Using FEA

Introduction, Vibration Problems, Free vibration and normal modes, The mode superposition method, Equation of motion Based on weak form and Lagrange's Approach, Consistent and Lumped mass Matrices, Properties and Solution of Eigen Value Problems, Transient Vibration Analysis.

Recommended Reading

1. Finite Elemenet Analysis By S.S. Bhavikatti, New Age International Publication.
2. Introduction to FEM by Desai and Abel
3. The Finite Element Method for Solid and Structural Mechanics –Zienkiewicz & Taylor, Elsevier Publications
4. Finite Element Analysis by J.N. Reddy, McGraw Hill Book Co.
5. Finite Element Method in Engineering by S.S.Rao, Pergamon Press
6. Textbook on Finite Element Analysis by P. Seshu, Prentise Hall Publications
7. Finite Element Analysis by Bathe and Wilson
8. Introduction to Finite Element Analysis by T. *Chandrupatla* and A. D. Belegundu, Prentice Hall
9. Finite Element Modeling For Stress Analysis for Robert D.Cook , John Wiley & Sons.
10. Computational Elasticity by Mohammad Ameen, Narosa Publishing House.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5042T**
Course Title	**Design of Suspension Systems**

Course Outcomes

The student should be able to–

1. Design suspension systems.
2. Select appropriate material for specific requirements of suspension systems.
3. Analyze causes of failure of suspension systems in service.

Course Contents:

Damper

Damper Configurations, Ride leveling Dampers Position Dependent ampers, Telescopic damper, Mountings, Operating speedsStrokes, Manufacture.

Damper Characteristics

Basic damper parameters, Mechanical Friction, Static Forces, Linear Valve Analysis, Cavitation, Temperature, Compressibility, Cyclical characteristics, Damper Jacking

Specifying a damper

Introduction, end fittings, length range, F(V) curve, configuration, diameter, oil properties, life, cost; active and passive suspensions

Testing of Dampers

Transient Testing, Electromechanical Testers, Hydraulic Testers, Instrumentation, Data Processing, Sinusoidal Test theory, Test Procedures, Triangular Test, Laboratory tests, On - Road Testing

Modeling of delayed dynamic systems

Mathematical models for dynamic systems with delayed feedback control, dynamic systems with operator's retardation.

Stability analysis of linear delay systems

Delay independent stability of single degree of freedom systems

Stability analysis of an active chassis

Quarter car model of suspension with a delayed sky-hook damper, four wheel steering with a time delay in driver's response.

Stability analysis of an active suspension

Center manifold reduction; computation of the approximated center manifold; stability analysis

Recommended Reading:

1. John C Dixon, The Shock Absorber Handbook, SAE Book Store, 1st Edition,1999.
2. Wolfgang Matschinsky, Road Vehicle Suspensions, Wiley Publishers,2nd Edition,2003.
3. Haiyan Hu, Zaihua Wang, Springer Dynamics of Controlled Mechanical Systems with Delayed Feedback, Verlag Berlin Heidelberg Publication.,2nd Edition, 1982.
4. George Bossis, Electro-rheological Fluids and Magneto-rheological Suspensions, World Scientific Publishing Co. Ltd., 2ndEdition, 1982.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5043T**
Course Title	**Automotive Noise vibration and Harshness**

Course Outcomes:

Upon completion of this course the student will be able to -

1. Identify sources of noise and vibration in automotive applications
2. Understand working of noise & vibration measuring instruments
3. Understand the principle of active noise cancellation
4. Understand noise control techniques
5. Understand signal analysis techniques

Course contents:

NVH in the Automotive Industry

Sources of noise and vibration, design features, common problems, pass-by noise requirements, target vehicles and objective targets, Vehicle structure noise, Engine noise, Transmission noise, Exhaust noise

Vibration Theory

Transient and steady state response of one degree of freedom system applied to vehicle systems, transmissibility, modes of vibration.

Basics of Sound

Sound measurement, human sensitivity and weighting factors, combining sound sources, acoustical resonances, properties of acoustic materials.

Test Facilities and Instrumentation

semi-anechoic rooms, Silent room, Modal Analysis, Data Acquisition system, Sound pressure level measurements, microphone, accelerometers, sound sources, Impedance tube, Transmission loss measurement, Sound absorption coefficient measurement, etc. Transducers, signal conditioning.

Signal Processing

Sampling, aliasing and resolution. Statistical analysis, frequency analysis, Campbell's plots, cascade diagrams, coherence and correlation functions.

NVH control Strategies & comfort

Source ranking, noise path analysis, modal analysis, vibration absorbers and Helmholtz resonators, active noise control techniques.

Recommended Reading

1. Noise and Vibration Control, Munjal, M.L. USA World Scientific Publishing Co. Pvt.Ltd.,2013.
2. Noise and vibration control engineering - principles and applications Ver, Istvanl, USA John Wiley & Sons, 2006.
3. Handbook of noise and vibration control Crocker, Malcolm J., Crocker, Malcolm J., USA John Wiley & sons, 2007.
4. Vehicle noise and vibration refinement Wang, Xu, Wang, Xu, USA Woodland Publishing Limited, 2010
5. Active control of noise and vibration, Hansen, Colin; Snyder, Scott; New York CRC PRESS,2013
6. Fundamentals of noise and vibration analysis for engineers, Norton Michael, Norton Michael, USA Cambridge University Press, 2nd ed., 2003
7. Vehicle refinement controlling noise and vibration in road vehicles (Book For PGA Students) SAE R-364 Harrison, Mattew, USA SAE.

Programme Elective-IV

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5051S**
Course Title	**Computational Fluid Dynamics**

Course Outcomes

The student should be able to –

1. Analyze methodologies used in CFD.
2. Apply finite volume method to heat transfer and fluid flow problems.
3. Develop computer codes for simulation of heat transfer and fluid flow problems.

Course Contents:

Fundamentals of CFD

Overview of CFD, need, Advantages of CFD, Numerical vs. Analytical vs. Experimental, Applications of CFD, CFD methodology, grid independence, Verification and validation

Governing equations of mass, momentum and energy

Derivation, Discussion of physical meanings and presentation of forms particularly suitable to CFD, Boundary Conditions – Dirichlet, Neumann, Robbins, initial conditions, mathematical behavior of partial differential equations – Elliptic, parabolic & hyperbolic equations, impact on CFD

Discretisation methods

Introduction to Finite Difference Method, Finite Volume Method, Finite Element Method. Concepts of Convergence, consistency, stability. Solution of discretised equations, Direct methods and iterative methods, Tri Diagonal Matrix Algorithm, iterative convergence

Finite volume method for diffusion problems (Conduction)

Steady state one dimensional heat conduction with or without heat generation, Dirichlet, Neumann, and Robins type boundary conditions, Multi-solid heat conduction, Non-linear Heat Conduction, Unsteady heat conduction-Explicit, Crank-Nicolson, Implicit schemes, stability of solutions, two dimensional steady and unsteady heat conduction. Gauss-Seidal point by point and line by line TDMA methods.

Finite volume method for Convection-diffusion problems

One dimensional convection-diffusion- Advection schemes-Central, first order upwind, exponential, hybrid, power law, Second order upwind, QUICK etc., Conservativeness, boundedness, transportiveness, False diffusion, Extension to two dimensional steady and

unsteady convection – diffusion

Solution algorithms for pressure velocity coupling

Staggered grids and co-located grids, SIMPLE, SIMPLER, SIMPLEC, PISO algorithms, unsteady flows

Geometry Modeling and Grid Generation

Domain discretization, Practical aspects of computational modelling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance

Turbulence modeling

Turbulence, Reynolds Averaged Navier-Stokes (RANS) equations, introduction to turbulence modeling - DNS, LES, k-ε , k-ω, RSM models

Recommended Reading

1. S V Patankar, Numerical Heat Transfer and Fluid Flow, Special Indian 1st Edition, Ane Books-New Delhi.
2. H K Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics-The Finite Volume Method, Second Indian Edition, Pearson Education, 2008
3. Atul Sharma, Introduction to Computational Fluid Dynamics: Development, Application and Analysis, John Wiely and Sons Ltd, 2017
4. Jiyuan Tu, Guan Heng Yeoh, Chaoqun Liu, Computational Fluid Dynamics: A Practical Approach, Elsevier, Third Edition, 2018
5. D. A Anderson, I.I. Tannehill , and R.H. Pletcher , Computational fluid Mechanics and Heat Transfer, CRC Press, 3rdEdition, 2012
6. John. D. Anderson, Jr., Computational Fluid Dynamics - The basics with applications, McGraw-Hill Education (India) , 1st Edition
7. Ferziger and Peric, Computational Methods for Fluid Dynamics, 3rd Edition, Springer, 2008

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5052S**
Course Title	**Automotive Aerodynamics**

Course outcomes:

The student should be able to –

1. Able to predict the drag and lift coefficients in the given case of fluid flow situation
2. Able to devise an experiment for carrying out aerodynamic analysis of the vehicle
3. Able to carry out numerical simulations by devising a fluid flow problems
4. Able to Predict variation in Aerodynamic forces and moments acting on vehicle bodywith changes in body shape
5. Able to understand effect of body shape on vehicle soiling

Course Contents:

Introduction

Scope – historical development trends – Fundamentals of fluid mechanics – Flow phenomenon related to vehicles – External & Internal flow problems – Resistance to vehicle motion – Performance – Fuel consumption and performance – Potential of vehicle aerodynamics.

Aerodynamic Drag of Cabs

Car as a bluff body – Flow field around car – drag force – types of drag force – analysis of aerodynamic drag – drag coefficient of cars – strategies for aerodynamic development – low drag profiles.

Shape Optimization of Cabs

Front and modification – front and rear wind shield angle – Boat tailing – Hatch back, fast back and square back – Dust flow patterns at the rear – Effect of gap configuration – effect of fasteners.

Vehicle Handling

The origin of force and moments on vehicle – side wind problems – methods to calculate forces and moments – vehicle dynamics Under side winds – the effects of forces and moments – Characteristics of forces and moments – Dirt accumulation on the vehicle – wind noise – drag reduction in commercial vehicles.

Wind Tunnels For Automotive Aerodynamic

Introduction – Principles of wind tunnel technology – Limitation of simulation – Stress with scale models – full scale wind tunnels –measurement techniques – Equipment and transducers – road testing methods –Numerical methods.

Recommended Reading

1. Hucho, W.H., Aerodynamics of Road vehicles, Butterworths Co. Ltd., 1997
2. Pope, A, Wind Tunnel Testing, John Wiley & Sons, 2nd Edn., New York, 1994.
3. Automotive Aerodynamics: Update SP-706, SAE, 1987.
4. Vehicle Aerodynamics, SP-1145, SAE, 1996.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5053S**
Course Title	**Automotive Electricals and Battery Management**

Course Outcomes

The student should be able to –

1. Explain the basics of battery power management, electric and hybrid electric vehicles and architecture.
2. Understand fuel cell applications in modern automotive.
3. Understand the basics of unmanned vehicles and working principles.
4. Analyze the use of power electronics for vehicle dynamics applications.

Course contents:

Electric Vehicles:

Introduction, Components, vehicle mechanics – Roadway fundamentals, vehicle kinetics, Dynamics of vehicle motion - Propulsion System Design.

Hybrid and Electric Vehicles (HEV):

History Overview and Modern Applications

Ground vehicles with mechanical powertrain and reasons for HEV development

HEV configurations and ground vehicle applications, Advantages and challenges in HEV design

Battery:

Basics – Types, Parameters – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge, Technical characteristics, Battery pack Design, Properties of Batteries.

Battery monitoring and charging control, Combination of batteries and ultra-capacitors.

Fuel cells:

Principles of operation, design, modeling, Fuel cell storage system, Strategy for controlling hybrid fuel cell system.

Power Flow and Power Management Strategies in HEV:

Mechanical power: generation, storage and transmission to the wheels, Electric power: generation, storage and conversion to mechanical power, Hydraulic power: generation, storage and conversion to mechanical power, Energy storage/conversion and thermodynamic relations.

Electric Unmanned Ground Vehicle: Computer Modeling and Physical Tests

Autonomous wheel power management for vehicle dynamics control.

Vehicle Dynamics Fundamentals for HEV Modeling and Computer Simulation (MATLAB/Simulink)

Various strategies for improving vehicle energy/fuel efficiency, Vehicle chassis mathematical model in various operation conditions (steady motion, acceleration, regenerating braking, coasting, moving up and down a hill)

Series HE powertrain mathematical model, Computer model of the HEV,, Computer Workshop. Fuel efficiency evaluation of a series HEV in city and high-way cycles: study

and analyze two strategies for ICE/Battery power split

Recommended Reading :

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2nd Edition, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology, Wiley publications, 1st Edition, 2003.
3. B D McNicol, D A J Rand, Power Sources for Electric Vehicles, Elsevier publications, 1st Edition, 1998.
4. Seth Leitman, Build Your Own Electric Vehicle MC Graw Hill, 1st Edition, 2013.

Open Elective-II

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5062S**
Course Title	**Future Vehicles and Green Technologies**

Course Outcomes:

At the end of the course, students will demonstrate the ability to -

1. Implement the different fuels and their feasibility as automotive fuels.
2. Predict and compare the performance characteristics of engine with different alternate fuels.
3. understand the emissions of an engine and their treatment techniques
4. Understand the procedure to select a fuel on basis of power output, performance, emission, engine size & applications.
5. Understand the measurement principle of emission analysers.

Course contents:

Emission from Automobiles

Sources of Air Pollution. Various emissions from Automobiles — Formation — Effects of pollutants on environment and human beings. Emission control techniques – Modification of fuel, after treatment devices. Emission standards. Automotive waste management, old vehicle disposal, recycling, tyre recycling..

Alcohols as Fuels

Alternative fuels. Availability of different alternative fuels for engines. Alcohols – Properties, Production methods and usage in engines. Blending, dual fuel operation, surface ignition, spark ignition and oxygenated additives. Performance, combustion and emission Characteristics in engines.Issues & limitation in alcohols

Bio-Fuels Vegetable Oils

Types of vegetable oils for engine application, Production, esterification, optimization of parameters to maximize the yield of biodiesel, biogas, properties, engine performance and emission characteristics. Vegetable oils and their important properties. Methods of using vegetable oils – Blending, preheating, Trans - esterification and emulsification –Issues & limitation in Vegetable Oils.

Hydrogen as Engine Fuel

Hydrogen – Properties, problems, Production methods, storage and safety aspects. Issues & limitation in Hydrogen. Methods of using hydrogen in engines. Performance, combustion and emission Characteristics in engines.

Fuel Cell: Working principle, classification, description of fuel cell systems, fuel cell components, properties of fuel cell, general performance characteristics, emission characteristics, merits and demerits, vehicle design and layout aspects.

Biogas, Natural Gas and LPG as Fuels

Biogas, Natural gas and LPG – Properties and production methods. CO_2 and H_2S scrubbing in Biogas, Modifications required for use in Engines- Performance, combustion and emission Characteristics in engines. Issues & limitation in Gaseous fuels.

CNG, LPG & LNG-

Availability, properties, modifications required in SI and CI engines, performance and emission characteristics, storage, handling and dispensing, safety aspects. Bi-Fuel Concept

Recommended Reading

1. Edward F. Obert, 'Internal combustion engines and air pollution' Harber and Row Publishers, 1973.
2. M.Khovakh, 'Motor Vehicle Engines', Mir Publishers, Mascow,1976
3. W.H.Crouse and A.L.Anglin, 'Automotive Emission Control', McGraw Hill Book Co, 1995.
4. G.S.Springer and A.J.Patterson, 'Engine emissions and pollutant formation', plenum press, Newyork,1986.
5. ARAI & Western Section Proceedings, I C Engine Design & Development, Jan 2009.
6. Ganesan.V, Internal Combustion Engines, Tata McGraw Hill, 1994.
7. Ayhan Demirbas, ' Biodiesel A Realistic Fuel Alternative for Diesel Engines', Springer-Verlag London Limited 2008,ISBN-13: 9781846289941
8. Gerhard Knothe, Jon Van Gerpen, Jargon Krahl,The Biodiesel Handbook, AOCS Press Champaign, Illinois 2005.
9. Richard L Bechtold P.E., Alternative Fuels Guide book, Society of Automotive Engineers, 1997 ISBN 0-76-80-0052-1.
10. Transactions of SAE on Biofuels (Alcohols, vegetable oils, CNG, LPG, Hydrogen, Biogas etc.).
11. Science direct Journals (Biomass & Bio energy, Fuels, Energy, Energy conversion Management, Hydrogen Energy, etc.) on biofuels.

Laboratory Courses

Programme Name	***Masters of Technology in Mechanical Engineering with Specialization in Automobile Engineering***
Course Code	**MEAE5074L**
Course Title	**Laboratory-4 Advanced Finite Element Analysis Laboratory**

Course Outcomes

After completion of course, students would be able to

1. To acquire basic understanding of Modeling and Analysis software ·
2. Be able to use the commercial Finite Element packages to build and solve selected problems.
3. To understand the different kinds of static analysis, find out the stress and other related parameters.
4. To learn to apply the basic principles to carry out dynamic analysis.

List of Experiments/Assignments

1. 1-D Element Problems –Linear Static Analysis
2. 2-D Element Problems – Linear Static Analysis
3. 3-D Element Problems – Linear Static Analysis
4. Free Vibration Analysis on Beam, Bars, Plates
5. Non-Linear Analysis of 1-D Element Problems Like Beams, Bars
   Thermal Analysis(Conduction, Convection and Insulation Boundary Conditions.
6. 1-D Element Problems-Steady state And Transient Analysis
7. 2-D Element Problems of Homogeneous and Composite Slap in Steady State and Transient Analysis
8. 3-D Element Problems Steady State Analysis
9. Project-Creating or Importing and Map Meshing of 3-D component /Assembly of practical application and FEA Analysis of Same component /Assembly

Recommended Reading

1. Finite Element Analysis using Ansys 11.0 by Paleti Shrinivas, Krisha Chaitnay Sambana, Rajesh Kumar Datti.
2. Finite Element Analysis Theory and Applications with ANSYS by Saeed Moaveni
3. Engineering Analysis with ANSYS Software by Y. Nakasone and S. Yoshimoto
4. The finite element method And applications in Engineering using Ansys® by Erdogan Madenci, Ibrahim Guven
5. Practical Finite Element Analysis by Nitin Gokhale of M/S Finite to Infinite.
6. Reference Manual of Hypermesh Software
7. Online Tutorial HyperMesh Software
8. Tutorial of Ansys Software.

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5075L**
Course Title	**Laboratory-5 Computational Fluid Dynamics Laboratory**

Course Outcomes -

The student should be able to –

1. Develop computer codes for simulation of heat transfer and fluid flow problems.
2. Implement CFD process by using CFD software.
3. Interpret data obtained from the numerical solution

List of Experiments

Students will use CFD software (commercial/open source) for solution of a problem (sample problems given in the list, however students can select their own project topic) and present their results.

GROUP A – Automotive Systems (any 4)

1 Flow between two parallel plates (laminar/turbulent) (with or without heat transfer)

2 Flow in pipe (laminar/turbulent)

3 Boundary layer on a flat plate

4 Flow in a bend

5 Flow over an aero-foil

6 Convection in a pipe (laminar/turbulent)

GROUP B – Automotive Systems (any 4)

1 CFD analysis of Lid-driven Cavity

2 CFD analysis of Ahmed Body

3 Assessment of Turbulence models for Ahmed Body

4 CFD analysis of vehicle aerodynamics and methods to reduce drag of vehicle

5 CFD analysis of a heat exchanger

6 CFD analysis of Combustion in Engines

Recommended Reading

1. Jiyuan Tu, Guan Heng Yeoh, Chaoqun Liu, Computational Fluid Dynamics: A Practical Approach, Elsevier, Second Edition, 2012
2. https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules
3. https://www.openfoam.com/documentation/

Programme Name	***Master of Technology in Mechanical Engineering with specialization in Automobile Engineering***
Course Code	**MEAE5076L**
Course Title	**Laboratory 6 Automotive System & Composite Materials Laboratory**

Course Outcomes

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

1. Illustrate the functioning of power steering, braking and transmission systems
2. Perform tests on chassis dynamometer
3. Perform tests on wheel alignment and onboard diagnostic
4. Evaluate the performance
5. Develop composite manufacturing process for the given part
6. Evaluate the performance of composite structure
7. Design the optimal composite structure

GROUP A – Automotive Systems (Any 5)

1 Assemble and Dismantle the Old vehicle to study the parts.

2 Study of Power steering system, Braking System, Gear Box and Clutch assembly

3 Wheel alignment test

4 Vehicle performance test using chassis dynamometer

5 Fuel consumption test

6 Study of vehicle lighting system

GROUP B – Composite Materials (Any 5)

1 Manufacturing of composite laminates using hand layup process
2 Manufacturing of composite laminates using VARTM process
3 Manufacturing of composites using compression molding
4 Manufacturing of Polymeric Nano-composites
5 Finite Element Analysis of Unidirectional Composites
6 Finite Element Analysis of Woven Composites
7 Finite Element Analysis of Short Fiber Reinforced Composites
8 Modeling of Delamination of Composites

Recommended Reading

1. Automobile Engineering,ByK.M.Gupta.l,Vol.I&II, UmeshPub, 2010
2. PEMFuelCells-TheoryandPractice,FranoBarbir,ElsevierAcademicPress-2005.
3. Electric vehicle technologyexplained,JamesLarmine, JohnWileyand Sons,2013.
4. P.K. Mallick, Fiber-Reinforced Composites: Materials, Manufacturing, and Design, CRC Press, Third Edition, 2007
5. ANSYS Composite PrepPost User's Guide, http://www.ansys.com