M. Tech (Automotive Technology)

Curriculum Structure

w.e.f AY 2019-20 and Applicable for batches admitted from AY 2019-20 to 2022-23

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	4	5.9%
PSBC	Program Specific Bridge Course	1	3	4.4%
DE	Department Elective Course	3	9	13.2%
MLC	Mandatory Learning Course	2	0	0%
PCC	Program Core Course	6	22	32.4%
LC	Laboratory Course	2	2	2.9%
IOC	Interdisciplinary Open Course	1	3	4.4%
LLC	Liberal Learning Course	1	1	1.5%
SLC	Self Learning Course	2	6	8.8%
SBC	Skill Based Course	2	18	26.5%

Program Educational Objectives (PEOs)

1. Pursue a successful career in automotive and Ancillary industries that meet the needs of Indian and multinational companies.
2. Synthesize the data and apply the technical concepts in the automotive applications.
3. Innovative and provide solutions by carrying out research.
4. Formulate, solve and analyze engineering problems using mathematical, scientific and engineering principles.
5. Will show professional and ethical attitude and maintain a lifelong learning attitude.

Program Outcome

An ability to independently carry out research /investigation and development work to solve practical problems
An ability to write and present a substantial Technical report/document.
Students should be able to demonstrate a degree of mastery over the area as per the Specialization of the program.
Students will be able to apply their knowledge of mathematics, science and automotive technology to the solution of complex problems in Automotive engineering.
Students will be able to design the complex automotive system, components, processes that meet the specified needs, with appropriate consideration for public health and safety along with social, cultural and environment considerations.
Students will be able to create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex automotive engineering activities with understanding of the limitations..

M. Tech (Automotive Technology)
Program Structure and Course Syllabus

Semester I

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme L	T	P	Credits
1.	PSMC	MAT-19001	Program Specific Mathematics Course (Computational Methods in Engineering)	3	1	--	4
2.	PSBC	MAT-19002	Automotive Engineering Systems (ARAI)	3	0	--	3
3.	DE -I	Department Elective –I		3	--	--	3
		MAT(DE)-19001	Combustion Engineering (COEP)				
		MAT(DE)-19002	Hybrid and Electric vehicles (ARAI)				
		MAT(DE)-19003	Modelling of Automotive Systems (COEP)				
		MAT(DE)-19004	Automotive Materials & Composites (COEP)				
		MAT(DE)-19005	Auto testing and Certification (ARAI)				
6.	PCC-I	MAT-19003	Automotive Fuels & Emission (ARAI/COEP)	3			3
7.	PCC-II	MAT-19004	Automotive Noise Vibration Harness (ARAI)	3			3
8.	PCC-III	MAT-19005	Vehicle Dynamics (COEP)	3			3
9	LC-I	MAT-19006	Automotive Lab-I:(ARAI & COEP)			4	2
			Total	**18**	**1**	**4**	**21**

Interdisciplinary Open Course (IOC): Every department shall offer one IOC course (in Engineering/Science/Technology). A student can opt for an IOC course offered by a department except the one offered by his /her department.

Semester II

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme L	T	P	Credits
1.	IOC	MAT-19007	Interdisciplinary Open Course	3	--	--	3
2.	MLC	ML-19011	Research Methodology and Intellectual Property Rights (COEP)	2	--	--	--
3.	MLC	ML-19012	Effective Technical Communication (COEP)	1	--	--	--
4.	DEC-II	**Department Elective –II**		3	--	--	3
		MAT(DE)-19006	Automotive Safety and Lighting (ARAI)				
		MAT(DE)-19007	Finite Element Method (ARAI)				
		MAT(DE)-19008	Computational Fluid Dynamics (COEP)				
		MAT(DE)-19009	E-Noise Vibraton Harshness (ARAI)				
		MAT(DE)-19010	Automotive Tribology (COEP)				
5.	DEC-III	**Department Elective –III**		3	--	--	3
		MAT(DE)-19011	Automotive System Design (COEP)				
		MAT(DE)-19012	Automotive Aerodynamics. (COEP)				

		MAT(DE)-19013	Automotive HVAC (ARAI)				
		MAT(DE)-19014	Automotive Transmission and Control				
		MAT(DE)-19015	Automotive Intelligence				
6.	LLC	LL-19002	Liberal Learning Course (COEP)	--	--	--	1
7.	PCC-I	MAT-19008	Automotive Mechatronics (ARAI)	3			3
8.	PCC-II	MAT-19009	IC Engine Modelling (COEP)	3			3
9.	PCC-III	MAT-19010	Automotive Engine Design (COEP)	3			3
10.	LC	MAT-19011	Auto Lab-II:(ARAI & COEP)			4	2
11.		MAT-19012	**Mini Project**			**4**	**2**
			Total Credits	21		8	23

Semester-III

Sr. No.	**Course Code**	**Course Code**	**Course Name**	**Teaching Scheme**			**Credits**
				L	T	P	
1.	SBC	MAT-20001	Dissertation Phase – I	--	--	18	9
2.	SLC	MAT-20002	Massive Open Online Course -I	3	--	--	3
			Total Credits	**3**		**18**	**12**

Semester-IV

Sr. No.	**Course Code**	Course Code	**Course Name**	**Teaching Scheme**			**Credits**
				L	T	P	
1.	SBC	MAT-20003	Dissertation Phase – II	--	--	18	9
2.	SLC	MAT-20004	Massive Open Online Course -II	3	--	--	3
			Total Credits	**3**		**18**	**12**

SEMESTER I

(PSMC) (MAT-19001) Computational Methods in Engineering

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. understand the mathematical models and methodologies to solve those models
2. analyze and develop the mathematical model of an engineering system.
3. solve differential equations using numerical techniques.

Syllabus Contents:

- Roots of Equations: Bracketing methods, open methods and case studies.
- Linear Algebraic Equations: Gauss Elimination, LU decomposition and matrix inversion, special matrices and Gauss-Seidel method, case studies.
- Numerical Differentiation and Integration: Newton-Cotes integration formulas, integration of equations, numerical differentiation, case studies.
- Ordinary Differential Equations: Runge-Kutta methods, stiffness and multistep methods, boundary value and eigen value problems, case studies.
- Partial Differential Equations: Finite difference methods for elliptic and parabolic equations, case studies.

References:

1. J.B. Doshi, “Differential Equations for Scientists and Engineers”, Narosa, 2010.
2. Peter O'Neil, “Advanced Engineering Mathematics”, Seventh Edition, Cengage Learning, 2012 (Indian Edition).
3. Michael Greenberg, “Advanced Engineering Mathematics”, Second Edition, Pearson Education, 2002 (Indian Edition).
4. Jennings. A., Matrix Computation for Engineers and Scientists. John Wiley and Sons, 1992.
5. Prem.K.Kythe, PratapPuri, Michael R.Schaferkotter, Introduction to Partial Differential Equations and Boundary Value problems with Mathematics, CRC Press,

2002.

6. Kreyszig, Erwin, I.S., Advanced Engineering Mathematics, Wiley, 1999.
7. Ramamurthy. V., Computer Aided Design in Mechanical Engineering., Tata McGraw Hill Publishing Co., 1987
8. Fundamental Concepts in the Design of Experiments, 5th Ed., by Hicks and Turner
9. Devore, Jay L., Probability and Statistics for Engineering and the Sciences, 5th edition, Brooks- Cole (1999)

(PSBC) (MAT-19002)Automotive Engineering Systems	
Teaching Scheme Lectures: 3 hrs/week	**Examination Scheme** T1, T2, – 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1: Identify the need of transmission system, it's function, and discuss different types of Passenger car transmission systems.

2: Calculate vehicle resistance, predict vehicle power requirement curve.

3: Calculate transmission gear ratio's & predict vehicle performance.

4: Categorize different vehicles bodies & layout's, it's nomenclature, structural elements and synthesis it to meet vehicle crashworthiness requirements.

5: Describe the different breaking & suspension systems in an automobile & demonstrate the vehicle safety.

Syllabus Contents:

Unit I: Introduction (4 Hrs)

History, Development of Vehicles & Drive Units, Stages in the Development of Automotive Transmissions, Development of Gear-Tooth Systems and other, Transmission Components. Basic Elements of Vehicle and Transmission Engineering, Need of Gearboxes, Functions of Vehicle Transmissions, and Fundamental Performance Features of Vehicle Transmissions, Trends in Transmission Design, Transmission Losses and Efficiency.

Basic Design Principles (6 Hrs)

Arrangement of the Transmission in Passenger / Commercial / All-Wheel Drive Passenger Cars / Transverse and Longitudinal Dynamics with All-Wheel Drive. Transmission Formats & Designs, Basic Gearbox Concept. Passenger Car Transmissions: Manual Passenger Car Transmissions (MT); Automated Manual Passenger Car Transmissions (AMT); Dual Clutch Passenger Car Transmissions (DCT); Automatic Passenger Car Transmissions (AT); Passenger Car Hybrid Drives; Continuously Variable Passenger Car Transmissions (CVT). Final Drives: Axle Drives for Passenger Cars, Axle Drives for Commercial Vehicles, Differential Gears and Locking Differentials, Hub Drives for Commercial Vehicles; Transfer Gearboxes.

Unit III: Passenger Vehicle Body (8 Hrs)

The Automobile Body, Description of the Automobile Body Types (space frame, central frame, Body-on-frame, Monocoque), Body Nomenclature, Body Mass Benchmarking, Steel used in passenger vehicle. Vehicle layout, Different types of Car Body Style, Automotive Body Structural Elements, Overview of Classical Beam Behavior, Design of Automotive Beam Sections, Design for Crashworthiness: Standardized Safety Test Conditions and Requirements, Front Barrier, Side Impact, Note on Rear Impact.

Unit IV: Brakes, Suspension Systems: (12 hrs)

Type of brakes, Disc & Drum brake theory, constructional details, advantages, Brake actuating systems, Materials, and braking torque. Factors affecting brake performance, Parking & Exhaust brakes, power assisted brakes, Antilock Breaking System (ABS). Testing of brakes, thermal Considerations.

Construction of suspension system, Solid Axles & Independent Suspension system, four-link & multi-link, Trailing Arm, Short Long Arm (SLA), MacPherson Strut suspension system, Anti-Squat, Anti-Pitch, and Anti-Dive suspension system, Roll Center& stability Analysis.

Tutorial: Developing a Traction Diagram and a Matlab code for given Engine & Transmission. (4 Hrs)

Text Books:

1. Harald Naunheimer, Bernd Bertsche, Joachim Ryborz, Wolfgang Novak “Automotive

Transmission: Fundamentals, Selection, Design & Application" 2nd Edition, Springer-Verlag Berlin Heidelberg 1994, 2011

2. Donald E. Malen "Fundamentals of Automobile Body Structure Design" SAE International Publication.
3. K. Newton, W.Steeds and T.K.Garret, "The Motor Vehicle", 13th Edition, Butterworth Heinemann, India, 2004.
4. P.M.Heldt, "Automotive Chassis", Chilton Co., New York, 1982.
5. W.Steed, "Mechanics of Road Vehicles", Illiffe Books Ltd., London. 1992.
6. Heinz Heisler, "Advanced Vehicle Technology", second edition, Butterworth – Heinemann, New York, 2002.

References:

1. William Crouse, "Automobile Engineering "
2. Harban Singh Rayat, "The Automobile", S. Chand & Co. Ltd, New Delhi, 2000.
3. G.J.Giles, "Steering Suspension and Tyres", Illiffe Books Ltd., London, 1975.
4. Kirpal Singh, "Automobile Engineering", Standard publishers, Distributors, Delhi, 1999.
5. G.B.S.Narang, "Automobile Engineering", Khanna Publishers, Twelfth reprint New Delhi, 2005.
6. R.P.Sharma, "Automobile Engineering", DhanpatRai& Sons, New Delhi, 2000.
1. Dr. N. K. Giri, "Automobile Mechanics", Seventh reprint, Khanna Publishers, Delhi, 2005
7. Automotive Hand book/ Robert Bosch, SAE, 2003.
8. 2. K.K. Ramalingam, "Automobile Engineering ", Scitech Publications (India) PVT.

MAT (DE)-19004 Automotive Materials and Composites

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

On completion of this module the student should be able to:

1. Make themselves familiar with advanced engineering materials and manufacturing processes.
2. Evaluate and arrive at material properties for automotive components and select appropriate materials

3. Recommend suitable manufacturing process to produce a component
4. Evaluate and match materials and manufacturing processes
5. Evaluate the cause for failure of the components due to material or manufacturing process and recommend the appropriate remedy to avoid the failure

Unit I: Introduction to Automotive Components and Materials:

AutomotiveComponents categories, Different materials used for automotive components, Functionality considerations of automotive parts, Factors influencing selection of materials for components. Influence of material properties on functionality and forming of components, Strengthening mechanisms and their need in automotive environment, Ferrous and nonferrous metals for automotive applications, Analysis of the relative merits and demerits of metallic materials for automotive applications. Non-metallic materials for automotive components. Thermo plastic and thermo sets usage based on the functionality requirement, Ceramic materials: Need for ceramics. Advantages and limitations of nonmetallic materials in automotive environments.

Unit II: Light Weight Materials for Engineering Applications:

Background and motivation of introducing light weight materials in automotive applications. Value vs. weight. Weight effect on fuel consumption. weight distribution in automotive. Crash safety laws. From function to the trinity of light weight design. Light weighting material implementations. Light weight automotive materials: Magnesium alloys, Aluminum alloys, advance high strength steels, carbon fiber composites. Efficient material utilization. Steel body in white. Further directions in automotive materials: environmental viewpoint and safety viewpoint. Improving crashworthiness. Multi material enabling. Design strategies to get light weight design. Hybrid design. CAE analysis and simulation for modeling of light weight materials.

Unit III: Advanced Manufacturing Process of Automotive Components:

Conventional casting and forging processes. Forming technology for light weight materials. Powder metallurgy, Non-conventional machining technologies like Ultrasonic machining, Water jet cutting, Electrochemical processing, Laser cutting etc., Joining technologies current and emerging: resistance spot welding, clinching, friction stir welding, Laser welding, Adhesive joining, structural adhesives, self piercing rivets, Thermal joining. Processing of Non-metallic materials for automotive components:Molding, Extrusion, Thermo forming, Foam molding and tooling, Processing of ceramics like Slip casting technique, etc.

Unit IV: Composites in Automotive Environment:

Need for composites, Properties of engineering composites and their limitations, Significance of Polymer, Metal and Ceramic matrix composite systems, Property correlation with reinforcement shape and distribution, Processing and application of different composites for automotive components.

Unit V: Selection of Materials and Manufacturing techniques:

Correlation of functionality of the component with material properties. Factors influencing material selection. Derivation of performance index based on the functionality of the component. Ashby technique for material selection. Shape factor. Selection of materials and processes based on the functionality, Manufacturing feasibility. Case studies.

Unit VI: Analysis of Component Failures Due to Materials and Processes:

Case studies on failure analysis of some components. Analysis of failure and identification of causes for failure. Suitable remedies to avoid failure same from material and process perspective. Case studies.

References:

1. M. F. Ashby and H. Shercliff, D. Cubon, (2007) *Materials Engineering Science, Processing and Design*, Butterworth Publications.
2. C. Brian, G. Patrick and J. Colin. (2007) *Automotive Engineering: Light Weight, Functional and Novel Materials*, Taylor & Francis.
3. M. P. Groover. (2005)*Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, 2nd edition, John Wiley & Sons.
4. W. D. Callister. (2005) *Materials Science and Engineering an Introduction*, 6th edition, John Wiley & Sons.
5. H. Yamagata. (2005) *The Science and Technology of Materials in Automotive Engines*, Yamaha Motor Co. Ltd., Japan Woodhead Publishing Limited.
6. G. Davies. (2003)*Materials for Automobile Bodies*, Butterworth-Heinemann Publications.
7. S. Kalpakjian and S. R. Schmid. (2003) *Manufacturing Engineering and Technology*, Pearson Education.
8. K. G. Budinski and M. K. Budinski. (2002) *Engineering Materials Properties and Selection*, 7th edition, Prentice-Hall of India.

MAT (DE)-19001 Combustion Engineering

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Understand basic principles and concepts of fuel combustion.

2. Build knowledge of theories of fuel combustion.

3. Analyze the thermal cycles .

4. Mathematically model the combustion of fuel.

Syllabus Contents:

Thermodynamics of Combustion: Premixed and diffusion combustion process in IC engines and gas turbines. First and Second Law of Thermodynamics applied to combustion- combustion Stoichiometry- chemical equilibrium, spray formation and droplet combustion.

Chemical Kinetics of Combustion: Fundamentals of combustion kinetics, rate of reaction, equation of Arrhenius, activation energy. Chemical thermodynamic model for Normal Combustion.

Flames: Laminar premixed – flame speed correlations- quenching, flammability, and ignition, flame stabilization, laminar diffusion flames, turbulent premixed flames- Damkohler number.

Burning of Fuels: spray formation & droplet behavior, gas turbine spray combustion, direct injection engine combustion, detonation of liquid – gaseous
mixture, combustion of solid fuels,

References:

Text Book :

1. Combustion Engineering – Gary L. Borman, Kenneth W. Ragland, McGraw Hill
2. Spalding.D.B., "Some fundamental of Combustion", Butterworth Science Publications, London, 1985.
3. Lewis.B.,Pease.R.N. andTaylor.H.S., "Combustion Process High Speed Gas Dynamics and Jet Propulsion Series ", Princeton University Press, Princeton, New Jersey, 1976.
4. Taylor.E.F. “The Internal Combustion Engines ", International Text Book Co., Pennsylvania, 1982.
5. V.Ganesan, ‘Internal combustion Engines’, Tata McGraw Hill Book Co, Eighth Reprint, 2005.
6. Ashley Campbel, “Thermodynamic analysis of combustion engine”, John book company, Newyork, 1979.
7. J.l.Ramos, “Modelling of Internal Combustion Engine”, Mcgraw hill book company

New york 1990

8. John. B. Heywood,'Internal Combustion Engines'", Tata McGraw Hill Co., Newyork, 1988.
9. Ganesan.V. "Computer Simulation of Spark Ignition Engine Process", Wiley eastern India Ltd, 1996.

MAT (DE)-19005 Automotive Testing and Certification

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Classify the vehicle and identify the regulations governing for each vehicle type
2. Perform and analyze the Static & Dynamic test of any vehicle
3. Perform various test related to vehicle engine emissions
4. Test and analyze the performance of vehicle components
5. Perform the tests to be done on the vehicle lighting system

Syllabus Contents:

1. **Introduction:**Specification & Classification of Vehicles (including M, N and O layout), Homologation & its Types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks.
2. **Static Testing of Vehicle:** Photographs, CMVR physical verification, Tyre Tread Depth Test, Vehicle Weightment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement Of Foot Controls For M1 Vehicle, Angle & Dimensions Measurement of Vehicle, The Requirement Of Temporary Cabin For Drive – Away – Chassis.
3. **Dynamics Testing of Vehicle:** Hood Latch, Gradeability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test. Engine power test (petrol & diesel), Indian driving cycle, Vehicle mass emission, Evaporative emission (petrol vehicles), **Vehicle Crash Testing.**
4. **Vehicle Component Testing:** Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes

Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre& Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW<1500 kg), Body block test, Head form test, Driver Field Of Vision, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, Airbag Test, Accelerator Control System.

5. **Vehicle Lighting Testing:** Installation requirement for lighting, signalling& reflective devices Installation, Conspicuity & Reflective Marking, Photometry Test: Performance requirement for lighting, signalling and reflective devices - Head lamp, Front lamp, direction indicator lamp, signalling lamp and Warning triangles.

References:

1. Indian Standards (IS)
2. Automotive Industry Standards (AIS)
3. ECE & EC Regulations/Standards
4. Robert Bosch GmbH, Bosch Automotive Handbook
5. Motor Vehicle Manual
6. Safety Regulations- Society of Indian Automobile Manufacturers.
7. Mrs. Rashmi Urdhwareshe, Automotive Industry: Regulations Scenario in India Senior Deputy Director, ARAI, ISA Vision Summit 2013

MAT (DE)-19002 Hybrid and Electrical Vehicles

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2, – 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Understand the basic components of the hybrid systems
2. Understand the variations (different types) of hybrid configurations
3. Develop understanding of batteries, and motors
4. Design and develop the hybrid and electric vehicles

5. Understand the speed control mechanisms for electric motors and generators
Syllabus Contents: Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: 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 hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency. Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle

References:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

MAT (DE)-19003 Modelling of Automotive Systems

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	T1, T2, – 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Model every automotive system for its performance
2. Model the control systems of an automotive
3. Carry out mathematical investigations of the system models

Syllabus Contents:

System model representation: Configuration form, State-space representation, input-output equation, Transfer function, State-space representation from the input-output equation. Linearization, Determination of operating point, Numerical solution of Nonlinear model.

Mechanical system modeling: Translational systems, Rotational systems, Mixed rotational and translational systems and Gear train systems. Modeling of Electromechanical systems, Thermal systems, Pneumatic systems and Hydraulic systems. Transient response of First-order systems and Second-order systems. Open loop and close loop control systems, Block diagrams. Signal flow graph, Mason's gain formula. Feedback characteristic of control systems.

Controller components: Sensors, Differencing and amplification, Actuators. Electrical components, Hydraulic components and Pneumatics components. Time resonance of

Second-order systems, Time response specifications. Steady state error for Unit step input, Unit ramp input and Unit parabolic input. Types of feedback control systems. Type-0 system, Type-1 system and Type-2 system.

Design specifications of second order system, Derivative error compensation, Derivative output compensation, Integral error compensation, Proportional plus Integral plus Derivative compensation.

System stability: Algebraic criterion, Hurwitz stability criterion, Routh stability criterion. Automobile vehicle Driveline model. ABS Control systems. Complete vehicle model.

References:

1. Dynamic Systems – Hung V. Vu , Ramin S. Esfandiari
2. Control Theory – I. J. Nagrath
3. Automotive Control Systems –U. Kiencke, L. Nielsen
4. Vehicle Dynamics – Ellis

(PCC I) MAT (19003) Automotive Fuels and Emission	
Teaching Scheme Lectures: 3 hrs/week	**Examination Scheme** T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes;

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

1. implement the different fuels and their feasibility as an 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 analyzers.

Syllabus Contents:

Introduction:

Estimate of petroleum reserve, need for alternate fuel, availability and comparative properties of alternate fuels. Overview of alternative fuel in India.

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

Alcohol– Production of alcohol, properties, blending of Methanol and Ethanol, engine design modifications required and effects of design parameters, performance and emission characteristic. Dual Fuel Concept

SVO / Bio-fuels –
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.

Hydrogen- Production methods, properties, performance and emission characteristics, storage and handling, safety aspects, automotive standards. Dual Fuel Concept with hydrogen.

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.

Emissions from SI & CI Engines and its Control: Emission formation in S.I. engines – Hydrocarbons – Carbon monoxide – Nitric Oxide, CO2, Soot, PM and PN. Effects of design and operating variables on emission formation in SI and CI engines.
In-cylinder controlling techniques of emission. PM vs NOx trade-off.

After-treatment Devices- DOC , DPF , NSC , SCR, Charcoal Canister Control for evaporative emission, Positive crank case ventilation system for UBHC emission reduction. EGR Systems Valve types , EGR Circuit types , EGR Cooler types, EGR- Types Internal , Low pressure , High pressure - ECU Functionalities and its architecture - how it controls engine.

Emission Measurement and Test procedure- Measurement of CO, CO_2, by NDIR. Hydrocarbon by FID – Chemiluminescent detector for NO_x measurement, Smoke meters – Dilution tunnel technique for particulate measurement. Procedures on Engine and Chassis Constant Volume Sampling procedures.

References:

Text Book :

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,1985.
5. ARAI & Western Section Proceedings, "I C Engine Design & Development", Jan 2009.
6. Ganesan.V, Internal Combustion Engines, Tata McGraw Hill, 1994.
7. Crouse.W.M, Anglin.A.L., Automotive Emission Control, McGraw Hill 1995.

Reference Books :

1. Ganesan.V, Internal Combustion Engines, Tata McGraw Hill, 1994.
2. Crouse.W.M, Anglin.A.L., Automotive Emission Control, McGraw Hill 1995.
3. Springer.G.S, Patterson.D.J, Engine Emissions, pollutant formation, Plenum Press, 1986
4. Patterson, D.J, Henin.N.A, Emissions from Combustion engines and their Control, Anna Arbor Science, 1985. Linden.D, Handbook of Batteries and Fuel Cells, McGraw Hill, 1995.
5. Maxwell et al, Alternative Fuel : Emission, Economic and Performance, SAE, 1995
6. Watson, E.B., Alternative fuels for the combustion engine, ASME, 1990
7. Bechtold, R., Alternative fuels guidebook, 1998.
8. Joseph, N., Hydrogen fuel for structure transportation, SAE, 1996.
9. Holt and Danniel, Fuel cell powered vehicles: Automotive technology for the future SAE, 2001.

(PCC-II) MAT (19004) Automotive Noise, Vibrations and Harshness	
Teaching Scheme Lectures: 3 hrs/week	**Examination Scheme** T1, T2, – 20 marks each, End-Sem Exam - 60
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

Syllabus Contents:

1.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 (6hrs)

2.Vibration Theory: Transient and steady state response of one degree of freedom system applied to vehicle systems, transmissibility, modes of vibration. (7hrs)

3. Basics of Sound : Sound measurement, human sensitivity and weighting factors, combining sound sources, acoustical resonances, properties of acoustic materials. (6hrs)

4. 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. (8hrs)

5. Signal Processing: Sampling, aliasing and resolution. Statistical analysis, frequency analysis, Campbell's plots, cascade diagrams, coherence and correlation functions. (6hrs)

6. NVH control Strategies & comfort: Source ranking, noise path analysis, modal analysis, vibration absorbers and Helmholtz resonators, active noise control techniques. (6hrs)

References:

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.

(PCCIII) MAT (19005) Vehicle Dynamics

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Student will be able to

1. Understand the dynamics of the automotive systems and its performance parameters.
2. Identify the driving/ braking resistances and their influences on vehicle dynamics.
3. To analyze dynamics systems such as suspension systems, body vibrations, steering mechanisms.
4. Understand ride characteristic of vehicle.
5. to identify, formulate, and solve engineering problems

Unit I: **[4 Hrs]**

Introduction to vehicle dynamics - Dynamics of the motor vehicle, Vehicle fixed coordinates system, Earth fixed coordinates system, Details of vehicle systems, wheel angles, Typical data of vehicles.

Unit II: **[7 Hrs]**

Tires - Types, axis system, mechanics of pneumatic tires-tire forces Tire forces and moments, Tire structure, Longitudinal and Lateral force at various slip angles, rolling resistance, Tractive and cornering property of tire. Ride property of tires. Conicity and Ply Steer, Tire models, Estimation of tire road friction.

Unit III: **[7 Hrs]**

Longitudinal dynamics - Forces and moments on vehicle, Equation of motion, Tire forces, rolling resistance, weight distribution, Tractive effort and Power available from the engine, Calculation of Maximum acceleration Braking torque, Braking Force, Brake Proportioning, Braking Efficiency, Stopping Distance, Prediction of Vehicle performance. ABS, stability control, Traction control.

Unit IV: **[8 Hrs]**

Lateral Dynamics - Steering geometry, Types of steering systems, Fundamental condition for true Rolling, Development of lateral forces. Steady state handling characteristics. Yaw velocity, Lateral Acceleration, Curvature response & directional stability.

Unit V: **[8 Hrs]**

Vertical Dynamics - Human response to vibrations, Sources of Vibration, Suspension systems, Functions of suspension system. Body vibrations: Bouncing and pitching. Doubly conjugate points. Body rolling. Roll center and roll axis, Stability against body rolling.

Unit VI: **[8Hrs]**

Mathematical Modeling of Vehicle - Quarter car suspension model; Half car suspension model; Full car suspension model for ride and road holding performance considering two degree freedom model for sprung & un-sprung mass, two degree freedom model for pitch & bounce and motion of vehicle on undulating road.

Text Books:

- Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", 2013, Society of Automobile Engineers Inc., ISBN: 978-1560911999
- J. Y. Woung , "Theory of Ground Vehicles", John Willey & Sons, NY.
- Rajesh Rajamani , "Vehicle dynamics and control", Springer publication.

Reference Books:

- J. G. Giles , "Steering, Suspension & Tyres", Ilete Books Ltd., London.
- W. Steed , "Mechanics of Road Vehicles", Ilete Books Ltd. London.
- P. M. Heldt , "Automotive Chassis", Chilton Co. NK.
- Reza N Jazar , "Vehicle Dynamics : Theory and Application", Springer publication.

(LC I) MAT-19006 Automotive Laboratory I

Teaching Scheme	**Examination Scheme**
Practical: 2 hrs/week	Term work submission: 100 marks

Course Outcome:

1. 1. Demonstrate the significance of experimentation and explore the possibility of carrying out engineering investigations
2. Acquire hands on experience on the various test-rigs, experimental set up
3. Measure the various technical parameters by instrument and by mathematical relationship
4. Validate actual performance of the system experimentally
5. Analyse experimental test data for further improvement of the system
6. Identify the effect of various parameters on the system and co-relate them
7. Understand selection of fuel on basis of power output, emission norms, engine size and applications

Syllabus Contents:

Any nine practical from the given list will be conducted as a part of Automotive Lab I

(A) AUTOMOTIVE FUELS AND EMISSION

1. Heat Rejection test (heat balance) on Tractor / Genset diesel engine
2. Performance test on Tractor / Genset diesel engine
3. Transient test cycle (ETC) generation, execution and regression analysis
4. Assessment of engine friction loss by Willians line method
5. Emission test on Tractor / Genset diesel engine on Eddy Current Dynamometer
6. Emission test on Heavy duty diesel engine on Transient Dynamometer
7. Swirl & Flow tests of ports on steady state flow bench
8. Emission test for SI engine 2/3/4 wheels on chassis dynamometer
9. Quality analysis of biodiesel at different mixing rates and temperatures
10. Evaluation of ignition limit and flame speed of various gaseous fuels (CNG/LPG) at various equivalence ratio
11. Analysis of carbonyl compound from exhaust emission using HPLC
12. Chemical characterization of Gasoline fuel
13. Chemical characterization of Diesel fuel

(B) NOISE, VIBRATION AND HARSHNESS

1. Demonstration of various noise and vibration measuring instruments
2. Modal analysis of automotive components

3. Measurement of Sound pressure level of automotive noise sources
4. Measurement of sound absorption coefficient of sound absorbing materials
5. Noise measurement of an electric motor
6. Vibration measurement of an electric motor
7. Measurement of sound transmission loss of sound absorbing materials
8. Measurement of vehicle pass by noise
9. Measurement of Sound power level of automotive noise sources

References:

A1. Ganesan. V, Internal Combustion Engines, Mc Graw Hill Education 2017

A2. John B Heywood, Internal Combustion Engine Fundamentals, Mc Graw Hill Education 2017

A3. Martyr, A. J.; Plint, M. A., Engine Testing: Theory and Practice, Butterworth-Heinemann 2012

B1. Norton, Michael; Karczub, Denis, Fundamentals of Noise and Vibration Analysis for Engineers,

Cambridge University Press 2003

B2. Ewins, D. J., Modal Testing: Theory, Practice and Application, Wiley India Pvt. Ltd. 2017

B3. McConnell, Kenneth G., Vibration Testing - Theory and Practice, John Wiley & Sons 2008

C1. Viano, David C., Role of the Seat in Rear Crash Safety, SAE International 2002

SEMESTER II

IOC (MAT-19007) Interdisciplinary course	
Teaching Scheme	**Examination Scheme**
Lectures: 1 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

List of IOC **(MAT-19007) Interdisciplinary course:**

1. Finite Element Method.
2. Mechanics of Composite Material.

M Tech (Mechanical Engineering)

(IOC-1) Finite Element Method

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course:

1. The student will be able to classify a given problem on the basis of its dimensionality as 1-D, 2-D, or 3-D, time-dependence as Static or Dynamic, Linear or Non-linear.
2. The students will be able to develop system level matrix equations from a given mathematical model of a problem following the Galerkin weighted residual method or principle of stationary potential.
3. While demonstrating the process mentioned in 2 above, he will be able to identify the primary and secondary variables of the problem and choose correct nodal degrees of freedom and develop suitable shape functions for an element, implement Gauss-Legendre scheme of numerical integration to evaluate integrals at element level, and assemble the element level equations to get the system level matrix equations. He will also be able to substitute the essential boundary conditions correctly and obtain the solution to system level matrix equations to get the values of the field variable at the global nodes.
4. The student will be able to state three sources of errors in implementing FEM and suggest remedies to minimize the same for a given problem, viz. Modelling errors, Approximation errors, and numerical errors.
5. The student will be able to obtain consistent and lumped mass matrices for axial vibration of bars and transverse vibration of beams and obtain fundamental frequency of natural vibration using the methods mentioned in the curricula.

6. The students will be able use MATLAB for implementation of FEM to obtain elongations at nodes of a bar subjected to traction and concentrated loads and prescribed boundary conditions
7. The students will be able to use commercial software like ANSYS or ABAQUS for implementation of FEM to obtain stress concentration due to a small hole in a rectangular plate subjected to traction on edges and concentrated loads at points on the edges and prescribed boundary conditions.

Syllabus Contents:

Unit 1: Introduction, Classification of problems – Dimensionality, time dependence, Boundary Value problems, Initial value problems, Linear/Non-linear, etc,

Unit 2: Differential equation as the starting point for FEM, steps in finite element method, discretization, types of elements used, Shape functions,

Unit 3: Linear Elements, Local and Global coordinates, Coordinate transformation and Gauss-Legendre scheme of numerical integration, Nodal degrees of freedom,

Unit 4: Finite element formulation, variational, weighted residual and virtual work methods, 1-D and 2-D problems from Structural Mechanics – Bar and Beam problem,

Unit 5: Plane stress and plane strain problems, Axi-symmetric problems – Axi-symmetric forces and geometry, computer implementation, higher order elements, iso-parametric formulation,

Unit 6: Eigen-value problems, Natural axial vibration of bars and transverse vibration of beams, Methods to find eigen-values and eigen-vectors.

References:

1. Chandrupatla and Belegundu "Introduction to finite elements in Engineering", Prentice Hall of India Pvt. Ltd. New Delhi, 2001.
2. Logan Deryl L., "A First Course in Finite Element Method", Thomson Brook/Cole, 3rd ed. 2002
3. Cook R.D. "Concepts and applications of finite element analysis" Wiley, New York, 1981.
4. Reddy J N, "Finite element Method", Tata McGraw Hill publishing Co Ltd, New Delhi, Ed. 2, 2003
5. Bathe K.J., Cliffs, N.J. "Finite Element Procedures in Engineering Analysis", Englewood. Prentice Hall, 1981.

(IOC-2)Mechanics Of Composite Materials

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

The student should be able to

1. Student will be able to understand the basic concepts and difference between composite materials with conventional materials.
2. Students will be able to understand role of constituent materials in defining the average properties and response of composite materials on macroscopic level.
3. Students will be able to apply knowledge for finding failure envelopes and stress-strain plots of laminates.
4. Students will be able to develop a clear understanding to utilize subject knowledge using computer programs to solve problems at structural level.

Syllabus Contents:

Unit 1. Introduction

Definition and characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus

Unit 2. Basic Concepts and Characteristics

Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials

Unit 3. Elastic Behavior of Unidirectional Lamina

Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters

Unit 4. Strength of Unidirectional Lamina

Micromechanics of failure; failure mechanisms, Macromechanical strength parameters, Macromechanical failure theories, Applicability of various failure theories

Unit 5. Elastic Behavior of Laminate

Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates

Unit 6. Hygrothermal Effects

Hygrothermal effects on mechanical behavior, Hygrothermal stress-strain relations, Hygro-thermoelastic stress analysis of laminates, Residual stresses, Warpage

Unit 7. Stress and Failure Analysis of Laminates

Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials

References:

1. Isaac M. Daniels, Ori Ishai, "Engineering Mechaincs of Composite Materials", Oxford University Press, 1994.
2. Bhagwan D. Agarwal, Lawrence J. Broutman, "Analysis and Performance of fiber composites", John Wiley and Sons, Inc. 1990.
3. Mathews, F. L. and Rawlings, R. D., "Composite Materials: Engineering and Science", CRC Press, Boca Raton, 2003.
4. Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press, 2004.
5. Mazumdar S. K., "Composaite Manufacturing – Materials, Product and Processing Engineering", CRC Press, Boca Raton, 2002.
6. Robert M. Jones, "*Mechanics* of Composite Materials", Taylor and Francis, Inc., 1999.

(MLC) ML -19012 Effective Technical Communication	
Teaching Scheme:	**Evaluation Scheme:**
Lectures: 1hr / week	**100M: 4 Assignments (25M each)**

Course Outcomes (COs):

1. Student will be able to
2. Produce effective dialogue for business related situations
3. Use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively
4. Analyze critically different concepts / principles of communication skills
5. Demonstrate productive skills and have a knack for structured conversations
6. Appreciate, analyze, evaluate business reports and research papers

Unit 1: Fundamentals of Communication [4 Hrs]

7 Cs of communication, common errors in English, enriching vocabulary, styles and registers

Unit 2: Aural-Oral Communication [4 Hrs]

The art of listening, stress and intonation, group discussion, oral presentation skills

Unit 3: Reading and Writing [4 Hrs]

Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers

Reference Books

1. Raman Sharma, "Technical Communication", Oxford University Press.
2. Raymond Murphy "Essential English Grammar" (Elementary & Intermediate) Cambridge University Press.
3. Mark Hancock "English Pronunciation in Use" Cambridge University Press.
4. Shirley Taylor, "Model Business Letters, Emails and Other Business Documents" (seventh edition), Prentise Hall
5. Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non-native speakers of English", McGraw Hill.

(MLC I) (ML-19011) Research Methodology And Intellectual Property Rights

Teaching Scheme	**Examination Scheme**
Lectures: 2 hrs/week	**Continuous evaluation**
	Assignments/Presentation/Quiz/Test

Course Outcomes (COs):

Student will be able to

a. Understand research problem formulation and approaches of investigation of solutions for research problems
b. Learn ethical practices to be followed in research
c. Apply research methodology in case studies
d. Acquire skills required for presentation of research outcomes (report and technical paper writing, presentation etc.)
e. Infer that tomorrow's world will be ruled by ideas, concept, and creativity
f. Gather knowledge about Intellectual Property Rights which is important for students of engineering in particular as they are tomorrow's technocrats and creator of new technology
g. Discover how IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario
h. Study the national & International IP system

1. Summarize that it is an incentive for further research work and investment in R & D, leading to creation of new and better products and generation of economic and social benefits.

Syllabus Contents:

Unit 1: **[5Hrs]**

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.

Unit 2: **[5Hrs]**

Effective literature studies approaches, analysis

Use Design of Experiments /Taguchi Method to plan a set of experiments or simulations or build prototype . Analyze your results and draw conclusions or Build Prototype, Test and Redesign

Unit 3: **[5Hrs]**

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

Unit 4 : **[4Hrs]**

Introduction to the concepts Property and Intellectual Property, Nature and Importance of

Intellectual Property Rights, Objectives and Importance of understanding Intellectual Property Rights

Unit 5 : [7Hrs]

Understanding the types of Intellectual Property Rights: -Patents-Indian Patent Office and its Administration, Administration of Patent System – Patenting under Indian Patent Act , Patent Rights and its Scope, Licensing and transfer of technology, Patent information and database. Provisional and Non Provisional Patent Application and Specification, Plant Patenting, Idea Patenting, Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies

Unit 6 : [4Hrs]

New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development, International Scenario: WIPO, TRIPs, Patenting under PCT

Reference Books:

1. Aswani Kumar Bansal : Law of Trademarks in India
2. B L Wadehra : Law Relating to Patents, Trademarks, Copyright,
    a. Designs and Geographical Indications.
3. G.V.G Krishnamurthy : The Law of Trademarks, Copyright, Patents and
    a. Design.
4. Satyawrat Ponkse: The Management of Intellectual Property.
5. S K Roy Chaudhary & H K Saharay : The Law of Trademarks, Copyright, Patents
6. Intellectual Property Rights under WTO by T. Ramappa, S. Chand.
7. Manual of Patent Office Practice and Procedure
8. WIPO : WIPO Guide To Using Patent Information
9. Resisting Intellectual Property by Halbert ,Taylor & Francis
10. Industrial Design by Mayall, Mc Graw Hill
11. Product Design by Niebel, Mc Graw Hill
12. Introduction to Design by Asimov, Prentice Hall
13. Intellectual Property in New Technological Age by Robert P. Merges, Peter S. Menell, Mark A. Lemley

LLC (LL-19002) Liberal Learning Course	
Teaching Scheme Lectures: 1 hrs/week	**Examination Scheme** T1, T2: 20 marks each, End-Sem Exam - 60
Course Outcomes: At the end of the course, students will demonstrate the ability to: 1. Take up a area of his choice and develop the learning at his/her own	
Syllabus Contents: The candidate has to select the course from the list declared at institute level. He/she has to develop the learning himself/herself under the supervisor allotted by the department. The examination as decided by the supervisor shall be conducted.	
References: The candidate may use the resources as per their convenience	

(PCC-I) (MAT-1008) Automotive Mechatronics

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcome:

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

1. Understand the basic components of automotive mechatronics and control systems.
2. Understand the basics of sensors, actuators and its interaction with automotive parameters
3. Understand the basics of electronic engine management system for SI and CI Engine Management System
4. Identify the use of multiplex networking for automotive applications
5. Identify the applications of automotive mechatronics in different sub-domains of automobiles

1. **Fundamentals of Automotive Mechatronics & Control System:** Fundamentals of Mechatronics, Electronics Components, Microprocessor, Ports, Memory, Buses, Microcontroller, Fetch-Execute sequence, Programming, Electronic Control Unit, Testing of Microcontroller Systems. Control System: Open and closed loop control strategies, PID control, Look up tables, Modern control strategies: Fuzzy logic and adaptive control.

2. **Sensors & Actuators:** Hall Effect, hot wire, thermistor, piezo electric, piezoresistive, based sensors. Introduction, basic sensor arrangement, types of sensors, oxygen concentration sensor, lambda sensor, crankshaft angular position sensor, cam position sensor, Mass air flow (MAF) rate, Manifold absolute pressure (MAP), Throttle plate angular position, engine oil pressure sensor, vehicle speed sensor, detonation sensor, emission sensors, Actuators: solenoid actuator, stepper motors, relays, electrohydraulic actuators.
3. **Electronic Engine Management System:** Electronics Fuel Injection, Types of EFI, TBI, MPFI & GDI, Ignition System, Electronic Ignition System and its advantages, Fuel control maps, CI Engine Management. Fuel injection system, parameters affecting combustion, noise and emissions in CI engines. Pilot, main, advanced, post injection and retarded post injection. Electronically controlled Unit Injection system. Exhaust emission control systems, 2 and 3-way catalytic converter.
4. **Automotive Tools, Diagnosis & Networking:** Wiring Harness, Limitations of Wiring Harness, Multiplex data bus, Basic principle of Networking, Classification of automotive multiplex bus, Controller Area Network, Local Interconnect Network, FlexRay, Most, Automotive Ethernet, Connected Cars. Diagnosis: tools and equipment, Oscilloscope, onboard diagnosis system, Electromagnetic compatibility & tests for EMC.
5. **Applications for different domains and current trends:** Lighting systems: LED, adaptive front lighting system, Comfort systems: Cruise control, adaptive cruise control, central locking, Electric mirrors, windows, multimedia systems, Safety & security systems: Airbag, Chassis Systems: ABS, TC, ESP, TPMS, Active Suspension, Active Steering system, Automatic Transmission, Use of Machine learning and data analytics for the automotive applications (ADAS, vehicle Autonomy, prognostics, health monitoring).

References:

1. Automotive Mechatronics: Automotive Networking, Driving Stability Systems, Electronics (Bosch Professional Automotive Information), by Konrad Reif, Springer Fachmedien Wiesbaden, 2014.
2. Automobile Electrical & Electronic Equipments - Young, Griffitns - Butterworths, London.
3. Understanding Automotive Electronics, Wiliam B. Ribbens, 5th Edition, Newnes, Butterworth–Heinemann.
4. Diesel Engine Management by Robert Bosch, SAE Publications, 3rd Edition, 2004
5. Gasoline Engine Management by Robert Bosch, SAE Publications, 2nd Edition, 2004
6. Understanding Automotive Electronics – Bechfold SAE 1998
7. Automobile Electronics by Eric Chowanietz SAE.
8. Fundamentals of Automotive Electronics - V.A.W.Hilliers - Hatchin, London
9. Automotive Computer & Control System – Tomwather J. R., Cland Hunter, Prentice Inc. NJ
10. Automotive Computers & Digital Instrumentation – Robert N. Brandy, Prentice Hall Eaglewood, Cliffs, NJ
11. The Fundamentals of Electrical Systems - John Hartly - Longman Scientific & Technical
12. Automobile Electrical & Electronic Systems – Tom Denton, Allied Publishers Pvt. Ltd.
13. Anderson, J. M., Nidhi, K., Stanley, K. D., Sorensen, P., Samaras, C., &Oluwatola, O. A. (2014). Autonomous vehicle technology: A guide for policymakers. Rand Corporation.
14. James D. Halderman, Advanced Automotive Electricity and Electronics, Pearson, 2013.

15. Tom Denton, Advanced Automotive Fault Diagnosis, Routledge, 2006.
16. Nicolas Navet, Francoise Simonot-Lion, Automotive Embedded Systems Handbook, CRC Press, 2008.

(PCCII)(MAT-19009) IC Engine Modeling

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Learn about advanced concepts being pursued for modeling of IC Engine.

2. Determine engine performance characteristics for IC Engine by Applying thermo-chemical principles of energy and chemical balances through appropriate modeling.

3. Identify engineering problems, formulate model and solve the problems using knowledge of mathematics science and engineering.

4.Create and analyse zero dimensional thermodynamic model of IC Engine combustion

5. Use and analyse of one dimensional commercial software.

Syllabus Contents:

- **Fundamentals:** Governing equations, Equilibrium charts of combustion chemistry, chemical reaction rates, and approaches of modeling, model building and integration methods, gas exchange through valves, engine and porting geometry, exhaust gas recirculation, valve lift curves, and William's line for friction.
- **Thermodynamic Combustion Models of CI Engines:** Single zone models, premixed and diffusive combustion models, combustion heat release using wiebe function, wall heat transfer correlations, ignition delay, internal energy estimations, two zone model, application of heat release analysis,Zeldovich mechanism for formation of NOx, HC, CO .
- **Fuel spray behavior:** Fuel injection, spray structure, fuel atomization, droplet turbulence interactions, droplet impingement on walls, breakup model.
- **Mathematical models of SI Engines**: Simulation of Otto cycle at full throttle, part throttle and supercharged conditions, Progressive combustion, Auto-ignition modeling, single zone models, mass burning rate estimation, Adiabatic flame temperature and flame speed model, Friction in pumping, piston assembly, bearings and valve train etc. friction estimation for warm and warm up engines.

References:

1. Haywood, "I.C. Engines", Mc Graw Hill.
2. Ramos **J** (1989**)** Internal Combustion Engine Modeling**.** Hemisphere Publishing

Company
3. C. D. Rakopoulos and E. G. Giakoumis, “Diesel Engine Transient
4. Operation Principles of Operation and Simulation Analysis”, Springer, 2009.
5. V. Ganeshan, “Internal Combustion Engines”, Tata McGraw Hill, New Delhi, 1996.
6. P.A. Lakshminarayanan and Y. V. Aghav, “ Modelling Diesel Combustion” Springer, 2010
7. Bernard Challen and RodicaBaranescu, “Diesel Engine Reference Book” Butterworth-Heinemann, 1999.

(PCC-III)(MAT-19010) Automotive Engine Design	
Teaching Scheme Lectures: 3 hrs/week	**Examination Scheme** T1, T2: 20 marks each, End-Sem Exam - 60

Course outcome:
At the end of the course, students will demonstrate the ability to:
1. Able to find the required engine power for given vehicle.
2. Able to select type of engine and it's layout for given vehicle.
3. Able to find basic dimensions of main engine parts like piston, connecting rod, crank shaft and valve gear.
4. Able to design inlet and exhaust system for optimum engine performance.
5. Able to gain basic knowledge of designing engine foundation and cooling system.

Syllabus Contents:

Determination of engine power, selection of engine type, engine swept volume, engine balancing: longitudinal and lateral forces, rolling, pitching and yawing moment, balancing of in-line and V-engines, Number of cylinders, stroke, bore

Combustion chamber design for SI and CI engines

Piston design: piston crown, piston skirt, skirt ovality, piston clearance, cylinder liners, piston pin, piston pin offset, piston rings, number of rings, position of rings

Connecting rod design: materials, CR length, shank design, small end design, end cap design, failure of CR, CR cap bolts

Crank shaft design: Firing order, crank shaft layout, journal design, web design, and crank pin design.

Cylinder block design: wall thickness, liner, water jacket

Crank case design, cylinder head design, inlet and outlet manifold

Design of cooling system: radiator

Engine foundations

Silencer design foundation

References:

1. P.M. Heldt, High Speed Engine Design
2. Gile, Engine Design
3. Biezenov and Grammel, Engine Balancing
4. Obert, IC Engines
5. Kovakh, Motor Vehicle Engine
6. Howerth, CI Engine design
7. Crouse, Engine Design

(DEC II) (MAT(DE)-19006) Automotive Safety and Lightening

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Identify different safety systems and its role in automobiles
2. Determine vehicle structural crashworthiness
3. Analyze and simulate vehicle in barrier impacts
4. Determine injury thresholds and apply trauma for analysis of crash injuries
5. Analyze pedestrian safety by use of pedestrian simulator
6. Design vehicle safety systems

Syllabus 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, modelling 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, Behaviour 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.

Light Measurements, Testing equipment, calibration and photometric practice: 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.

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

References:

1. Watts, A. J., et al "Low speed Automobile Accidents" Lawyers and Judges 1996
2. JullianHappian-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.
6. Olson L. P, Forensic aspects of driver perception and response, Lawyers and Judges 1996.
7. Pantazis. M, Visual instrumentation: Optical design & engineering Principles, McGraw - Hill 1999.
8. Matthew Huang, "Vehicle Crash Mechanics".
9. David C. Viano, "Role of the Seat in Rear Crash Safety".
10. Jeffrey A. Pike, "Neck Injury".
11. Ching-Yao Chan, "Fundamentals of Crash Sensing in Automotive Air Bag Systems".
12. Rollover Prevention, Crash Avoidance, Crashworthiness, Ergonomics and Human Factors", SAE Special Publication, November 2003.

(DEC-II) (MAT(DE)-19007) Finite Element Methods	
Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Understand the mathematical and physical principles underlying the FEM.
2. Understand the behavior of various finite element methods.
3. Prepare problem definition, understand governing equation, boundary conditions, initial conditions, etc. for the automotive engineering problems
4. To carry out the simulations for structural, dynamic, NVH and crash analysis using commercial FEM code
5. Analyze the FEM results through post processing to obtain engineering parameters.

Syllabus Contents:

1. Introduction: Basic concepts of FEM, Relevance and scope of FEM, Brief Introduction to different Numerical Methods, Basics of statics and strength of material (Uni-axial, Bi-axial and Tri- axial stress), Introduction of meshing, Types of Elements, deciding element types, 1-D, 2-D, 3-D elements, Meshing techniques.

CASE Study.

2. 1-D, 2-D, 3-D Meshing: When to use 1-D elements, Stiffness matrix derivation, Stiffness matrix – assembly, Beam elements, Special feature of beam elements, When to use 2-D elements, Thin Shell elements, Mesh Density and Biasing, Symmetric Boundary Condition, Quality Checks, When to use 3-D elements, DOFs for Solid Elements, Tetra Meshing, Quality Checks, Special Elements: GAP Elements, Mass Elements, Spring and Damper Elements, Rigid and Constraint Elements, Weld Elements – Spot weld, Arc weld, Bolted Joints.

CASE Study.

3. Static and Dynamic analysis: Material Properties for Crash, Durability, NVH, Linear Static Analysis: Definition, Linear Static Solver, Solution Restart Method, H-Element Vs P-Element, Linear Buckling Analysis, Non-linear Analysis: Comparison of Linear and Non-Linear FEA, Types of Non-linearity, Convergence of solver, Dynamic Analysis: Why Dynamic Analysis, Static Analysis Vs Dynamic Analysis, Time Domain Vs Frequency Domain, Simple Harmonic Motion, Free Vibration, Force Vibration, Dynamic Analysis Solvers.

CASE Study.

4. Fatigue and Crash analysis: Fatigue Analysis: Why Fatigue Analysis, Static, Dynamic and Fatigue Analysis Comparison, Stress Life Approach, Strain Life Approach, Cycle Counting, Multi-axial Fatigue, Welding Analysis. Crash Analysis: Transient Dynamic Solution Methodology, Comparison of Explicit Vs Implicit Methods, Dynamic Vs Quasi- Static Simulation.

CASE Study.

5. NVH analysis and post processing techniques: Introduction to NVH Concepts, Frequency Range of FE Dynamic Analysis, FEA for Acoustics, Vibration and Noise Control, Post Processing Techniques: Validation and accuracy of the result, Viewing results, Interpretation of Results and Design Modification, CAE Reports.

CASE Study.

References:

1. O.C. Zienkewitz and Taylor, The Finite Element Method, Vol. I & II, McGraw Hill, 1991.
2. J.N. Reddy, An Introduction to Finite Element Method, McGraw Hill, 1993.
3. S.S.Rao, The finite element method in Engg.,Pergamon Press, 1993.
4. M.J.Fagan, Finite Element Analysis Theory and Practice, Longman Scientific and Technology, 1992.
5. R.D.Cook, Concepts and Applications of Finite Element Analysis, John Wiley & sons Inc., 1995

(DEC-II) (MAT(DE)-19008) Computational Fluid Dynamics

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Understand the discretization procedure of the governing equations
2. Prepare the problem definition of a given fluid flow heat transfer problem
3. Decide the governing equations, boundary conditions, initial conditions etc for the given problem
4. To carry out the simulations and obtain the results in terms of dependent variables
5. Analyze the CFD results through post processing to obtain engineering parameters

Syllabus Contents:

Introduction to CFD: Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations.

Governing Equations: Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy.

Finite Volume Method: Domain discretizations, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach

Geometry Modelling and Grid Generation: Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance

Methodology of CFDHT: Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation

Solution of N-S Equations for Incompressible Flows: Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows

References:

1. Computational Fluid Dynamics, The Basic with applications by John A. Anderson, Jr., McGraw Hill International editions, Mechanical Engineering series.
2. Numerical Methods in Fluid Flow & Heat Transfer by Dr. SuhasPatankar.
3. An Introduction to Computational Fluid Flow (Finite Volume Method), by H.K. Versteeg, W.Malalasekera, Printice Hall
4. Computational Methods for Fluid Dynamics by Ferziger and Peric, Springer Publication.
5. An Introduction to Computational Fluid Mechanics by Chuen-Yen Chow, Wiley Publication.
6. Computational Fluid Flow & Heat Transfer by Murlidhar and Sundarrajan, Narosa Publication.

(DEC II) (MAT(DE)-19009) E-NOISE VIBRATION AND HARSHNESS(E-NVH)

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	T1, T2, – 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Understand electrical motor noise behavior.
2. Understand electric power sources in the driveline and its NVH impact
3. Understand Driveline NVH characteristics
4. Understand Electric vehicle Sound Quality

Unit 1-Sources of Noise in Electrical Machines: Classification of noise sources in electrical machines, electromagnetic noise of electrical machines, aerodynamic noise of electrical machines, mechanical noise of electrical machines.

Unit 2-Electromagnetic Noise and Vibration: magnetostriction and Maxwell forces, humming noise, whining noise, Maxwell stress, resonance effects, wavenumber.

Unit 3-Noise Mitigation Techniques for Electrical Machines: reduction of the structural response independently of the electromagnetic excitations, reduction of the electromagnetic excitations independently of the structural response, reduction of the number of resonances occurring between electromagnetic excitations and structural modes.

Unit 4-Electric Vehicle NVH: NVH behaviour of electric motors and electric components, electromagnetically-excited acoustic noise and vibrations, transfer paths of electromagnetic noise and vibrations.

Unit 5-Driveline NVH: Characteristics, electric motor noise analysis and transmission noise, Integration electric power sources in the driveline for minimum NVH impact.

Unit 6-Electric Vehicle Sound Quality: differences between ICE vehicle and electric vehicle noise, use of Sound Quality metrics in the context of EVs.

References:

1. James Larminie and John Lowry, *Electric Vehicle Technology Explained,* 1st Edition, Wiley, 2003
2. Jacek F. Gieras, Chong Wang and Joseph Cho Lai, *Noise of Polyphase Electric Motors*, Taylor&Francis Group, 2006.

(DEC III) (MAT(DE)-190010) Automotive Tribology

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	T1, T2, – 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. visualize and interpret nature of friction and wear in various vehicle components like Engine, Transmission system, Tyres.
2. predict complete lubrication requirement of an automobile
3. develop the lubrication system for automobile system
4. evaluate the performance of automotive lubrication systems
5. study the effect of tyre construction on friction between tyre and road and tyre wear.

Syllabus Contents:

Introduction to Tribology: Friction, wear and lubrication principles of tribology, thick film lubrication, boundary layer lubrication.

Friction and wear: Laws of friction, causes of friction, types of wear and mechanisms of wear, wear properties of friction and anti-friction metallic and non-metallic materials.

Lubricants: Solid lubricants, liquid lubricants, properties of lubricants. selection for general applications and special applications such as low temperature, high temperature, extreme pressure, corrosion resistance etc.

Hydrodynamic lubrication: basic concepts, Reynolds equation, plane bearings. design of journal bearings- short and finite bearings, design of bearings with steady load, varying load and varying speed.

Lubrication of automobile systems: Engine lubricating systems, lubrication of piston, piston rings and cylinder liners, lubrication of cam and followers, lubrication of involutes gears, hypoid gears and worm gears, friction aspects of clutch, brakes and belt drive.

Pneumatic tyres: creep and slip of an automobile tyre, functions of tyre, design features of the tyre surface, mechanism of rolling and sliding, tyre performance on wet road surface.

References:

1. Principles and applications of tribology – Desmond F. Moore
2. Tribology in machine Design – T.A. Stolarski

3. Introduction to Tribology of Bearings – B.C. Majumdar
4. Vehicle Dynamics – Dr Georg Rill

(DEC-III) (MAT(DE)-19012) Automotive Aerodynamics

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	T1, T2: 20 marks each, End-Sem Exam - 60

Course outcome:

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 body with changes in body shape
5. Able to understand effect of body shape on vehicle soiling

Syllabus 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 Aerodynamics: 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.

References:

Textbook:

1. Hucho, W.H., Aerodynamics of Road vehicles, Butterworths Co. Ltd., 1997.

Reference Books:

1. Pope, A, Wind Tunnel Testing, John Wiley & Sons, 2nd Edn., New York, 1994.
2. Automotive Aerodynamics: Update SP-706, SAE, 1987.
3. Vehicle Aerodynamics, SP-1145, SAE, 1996.

(DEC-III) (MAT(DE)-19011) Automotive System Design	
Teaching Scheme Lectures: 3 hrs/week	**Examination Scheme** T1, T2: 20 marks each, End-Sem Exam – 60

Course Outcomes:

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

1. Understand the basic failure theories for all the systems
2. Design the automotive systems and check its failures.

Syllabus Contents:

Introduction to Design Process: Factors – Materials selection direct - Bending and Torsional stress equation - Impact and Shock loading - Stress concentration factor - Size factor - Surface limits factor - Factor of safety - Design stress - Theories of failures – Problems.

Fatigue strength and design of springs: Variable and cyclic loads – Fatigue strength – S- N curve – Continued cyclic stress – Soderberg and Goodman equations – Design of Helical – Leaf - Disc springs under Constant and Varying loads.

Design of Couplings: Design and drawings of couplings – Rigid – Flexible – Design and Drawings of Cotter joints - Knuckle joints, Computer aided design of machine elements.

Design of Clutches and Gear Boxes: single plate, multiple plates, centrifugal clutch, lining

material, lever design, sliding mesh, constant mesh, synchromesh gear box, gear ratio and gear shifting lever, sliding mechanism

Design of Drivetrain: Design of propeller shaft and U-joints, Design of propeller shaft,criteria,failure theories,u-joint design, Design of Final drive and differential, Design of bevel, worm and hypoid type of final drive ,differential.

Design of axel and Steering: Axle and shaft design, design of fully floating, half floating axle and dead axle, Steering gear and steering mechanism design, geometry for correct steering, linkages

Design of brakes and Suspension: internal expanding shoe brake, braking condition, friction lining material, mechanical and hydraulic braking system, leaf spring, coil spring, materials, suspension system and linkages, independent suspension

Automotive Body Structures: Emphasis is on body concept for design using first order modelling of thin walled structural elements. Practical application of solid/structural mechanics is considered to design automotive bodies for global bending, torsion, vibration, crashworthiness, topology, material selection, packaging, and manufacturing constraints.

References:

Text Books:

1. Joseph Edward Shigley and Charles, R. Mischke, (2000), Mechanical Engineering Design, McGraw –Hill International Editions.
2. Pandya and Shah, Machine design, Charotar Publishing House.

Reference Books:

1. DTB Donkins, Elements of Motor Vehicles Design, TMH
2. P. Lukin, Automobile Chasis Design and calculations, Mir Publishers
3. K. M. Agrawal, Autodesign Problems, Satyaprakashan.
4. N.K.Giri, Automotive Mechanics, Khanna Publishers.

(DEC-III) (MAT(DE)-19013) Automotive Heating, Ventilation and Air Conditioning

Teaching Scheme **Examination Scheme**

Lectures: 3 hrs/week T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Understand the requirements of HVAC in automobile applications
2. Understand the refrigerant and air managements
3. Develop the control system
4. Diagnosis the problems with HVAC systems

Syllabus Contents:

Fundamentals of Air-Conditioning, Cooling and Heating System: Basic terminology, design factors and concepts related to air conditioning system- Construction and Working principles of Thermostatic Expansion valve and Orifice tube based system- Heating system types -detailed study of HVAC components like compressor, evaporator, condenser, TXV, orifice tube , Receiver-drier, heater core etc. Location of air conditioning components in a vehicle.

Refrigerants & Air Management Systems: *Refrigerants:* Temperature and pressure relation, Properties of R-12 and R134a- refrigerant oil Simple problems - Containers - Handling refrigerants - Tapping into the refrigerant container - Ozone Layer Depletion.

Air management system: Air routing for manual, semi and automatic system- cases and ducts- Air distribution, control head and doors- Defrost system, Refrigerant charging, system installation.

Automatic Climate Control System: ATC system block diagram- different types of Sensors and Actuators, - Control Logic Electrical wiring diagram of manual and automatic system - multiplexing between BCM and PCM- control of compressor clutch, blower motor etc.- diagnostics tools and features.

Modeling of Air-Conditioning Components: Modelling of Fixed and variable Displacement type compressor, evaporator modeling - heat transfer correlations for the fluids inside the evaporator, analysis of evaporator frosting- condenser modeling -improvement of refrigerant flow control method.

Air Conditioning Diagnosis And Services: AC system diagnosis based on temperature and

pressure measurements, sight glass, sound etc. - refrigerant leak detection- Trouble shooting and Servicing of compressor, evaporator, condenser, heater core etc. – HVAC equipment , recovery and charging.

Air routing system service.

Textbooks:

1) Tom Birch, “Automotive Heating and Air Conditioning” Pearson Education Inc., 2003.
2) Boyce H. Dwiggins, Jack Erjavec., “Automotive Heating and Air-Conditioning”, Delmer publisher., 2001.
3) William H Crouse and Donald L Anglin, “Automotive air conditioning”, McGraw - Hill Inc., 1990

References:

1) Goings. L.F., “Automotive air conditioning”, American Technical services, 1974
2) Paul Weiser, “Automotive air conditioning”, Reston Publishing Co Inc., 1990.
3) MacDonald, K.L., “Automotive air conditioning”, Theodore Audel series, 1978.
4) James D. Halderman, “Automotive Heating, Ventilation, and Air Conditioning Systems”, Pearson Education Inc., 2004.
5) SAE paper No: 931121,900084, 850040,931137,870029 etc.
6) Vehicle Service Manuals.
7) ASHRAE Handbook, All four volumes.

(DEC-III) (MAT(DE)-19014) Automotive Transmission and Control	
Teaching Scheme Lectures: 3 hrs/week	**Examination Scheme** T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Understand basics of automotive transmission.
2. Understand shift mechanism and clutch control.
3. Get familiar with function development of transmission control systems.
4. Understand various types of transmission such as AT, AMT, MT.

Syllabus Contents:

Unit 1 :Introduction to Automotive transmission: Working principle and construction of Automotive Transmissions, Types of automotive transmissions, Manual Transmissions, CVT, DCT

Unit 2-Transmission System Design : Transmission requirement in a vehicle, gear ratios, Selecting the Ratios, Overall Gear Ratio, Selecting the Largest Powertrain Ratio, Selecting the Smallest Powertrain Ratio, Final Ratio. Selecting the Intermediate Gears, matching of powertrain.

Unit 3-Automated Manual Transmission (AMT) & Automatic Transmission (AT) : Introduction to Automated manual transmissions, working and construction, different configurations of AMT, actuators in AMT, Automatic transmission, working and construction, shifting strategies, features of AMT & AT, comparison with MT

Unit 4-Transmission Control System : Introduction to Transmission Control System, Transmission control unit, Function Development of Transmission Control System, Sensors and Actuators

Unit 5-EV transmissions : Requirements of transmission in electric vehicle, features of EV transmission, types, configurations, performance parameters , design consideration for EV transmission,

Unit 6-Hybrid Vehicle Transmission : HEV requirements of torque, different types of configurations in HEV, performance of hybrid transmissions, design parameters of HEV transmission systems

References:

1. Vehicle Powertrain Systems, BehroozMashadi , David Crolla, John Wiley & Sons, Ltd, 2012
2. Automotive Engineering Powertrain, Chassis System and Vehicle Body, David Crolla, Butterworth-Heinemann, 2009
3. Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives 1st Edition, Chris Mi , M. AbulMasrur , David Wenzhong Gao , Wiley; 2011
4. Electric Vehicle Technology Explained 1st Edition, James Larminie, John Lowry , Wiley; 2003.

(DEC-III) (MAT(DE)-19015) Automotive Intelligence	
Teaching Scheme Lectures: 3 hrs/week	**Examination Scheme** T1, T2: 20 marks each, End-Sem Exam - 60

Objective: Upon completion of this course, the students will
1. Understand the relation between system and signals,
2. Apply the knowledge of intelligence to automotive domain
3. Explore various tools in the field of intelligence awareness
4. Know enough on the neural network as applied for automotive application
5. Learn different ways to extract and retrieve information from automobile

Unit 1: Basics of Intelligence (6hrs theory + 4hrs in-class problem solving and analysis)
Definition of intelligence, systems blocks for data collection (data gathering), data pruning/cleaning and sanity checks (levels and understanding), use or adaptation beyond data; relating systems and signals (concept of deterministic and stochastic processes), data and its properties, statistical measures and tests, automotive applications.

Unit 2: Feature Extraction (6hrs + 2hrs in-class analysis - math rigour)
Transformation, transforms, necessity and purpose, feature domain, Occam's razor, math of transform, feature minimization, windowing, time frame, relevant automotive applications.

Unit 3: Neural Network and its implementation (4hrs + 10hrs)
Basics of Neural network, multiple hidden layers, convolution, open source framework (such as Tensorflow and Autoware), programming framework.

Unit 4: Sensors and Communication (6hrs)
LiDAR, RADAR, Camera - specifications and utilization, CAN OBD, communication - V2V, VI, V2X, Internet of Cars.

Unit 5: ADAS Applications (6hrs)
Simultaneous localization and motion, path planning, ambience awareness, driver drowsiness and intent detection, machine learning algorithms for automotive applications.

Unit 6: What Next in Automotive Intelligence (6hrs)
Prognostics and diagnostics of moving vehicle, vehicle health monitoring and status checks, last mile mobility solutions, trends and future of automotive intelligence (dialog system, speaker awareness).

Books:
1. Lawrence Burns, Autonomy
2. Tensorflow - Google website
3. Reports on Automotive Intelligence by various agencies such as McKinsey, PricewaterhouseCooper (PwC), Standard chartered, IBM, NITI Aayog
4. DARPA Projects on Automobility

(LC-II) (MAT-19012) Mini Project	
Teaching Scheme Contact hours: 4 hrs/week	**Examination Scheme** Presentation/demonstration–100 ESE
Course Outcomes: At the end of the course, students will demonstrate the ability to: 1. Carry out the given engineering problem independently. 2. Present the engineering analysis effectively. 3. Learn to write technical reports.	
Syllabus Contents: Mini project includes a small dissertation work which shall cover topics such as design, fabrication, analysis, simulations, field study, market survey and case study	

(LC-III) (MAT-19011)Automotive Lab II	
Teaching Scheme Practical: 4 hrs/week	**Examination Scheme** T1, T2: 20 marks each, End-Sem Exam - 60

Course Outcomes:

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

1. Demonstrate the significance of experimentation and explore the possibility of carrying out engineering investigations
2. Acquire hands on experience on the various test-rigs, Experimental set up
3. Measure the various technical parameters by instrument and by mathematical relationship
4. Validate actual performance of the system experimentally
5. Analyse experimental test data for further improvement of the system
6. Identify the effect of various parameters on the system and co-relate them
7. Demonstrate the algorithm, its coding and its use for automotive application

Syllabus Contents:

The term work shall consist of minimum six exercises approved by the PCC teachers.

List of Experiments:

Automotive Mechatronics:

1. Design of 5V DC power supply
2. Design of LED Flasher circuit using IC555 Timer
3. Design of Traffic Light Controller using Arduino Uno
4. Variation of LED intensity and blinking using Arduino and Potentiometer
5. Distance measurement using ultrasonic sensor and Arduino Uno
6. Displaying voltage on 16x2 LCD Display using Arduino Uno
7. Automatic lights using LDR and Arduino Uno
8. Radiated Emission test of Automotive Electronic Components using GTEM Cell
9. Development of a Simulink model of DC Motor speed control

AUTOMOTIVE SAFETY AND LIGHTING LABORATORY

1. "H" point measurement on 3-D manikin
2. Static and dynamic testing of air bags
3. Anthropometric measurement using 3d scanner
4. Demonstration and calibration of dummy
5. Rear view mirror testing
6. Performance evaluation of signalling devices

7. Testing and evaluation of lighting devices
8. G lock testing of seat belt
9. Impact testing of bumpers

   Seat belt anchorage test

References:

1. Denton, Tom., Automobile Electrical and Electronic Systems, Routledge 2018
2. Ribbens, Williams B., Understanding Automotive Electronics: An Engineering Perspective, Butterworth–Heinemann 2017
3. Tyagi, Agam Kumar, Matlab and Simulink for Engineers, Oxford University Press

Semester III

(SBC) (MAT-20001) Dissertation I	
Teaching Scheme Practical: 18 hrs/week	**Examination Scheme** End-Sem Exam –20/20/60

Course Outcomes:

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

1. critically read, interpret & evaluate current literature in the discipline.
2. integrate and synthesize ideas within the field.
3. demonstrate comprehensive knowledge of the literature in the field
4. critically evaluate empirical evidence.
5. demonstrate a comprehensive understanding of techniques critical to the field
6. Able to communicate clearly and effectively to specialist and non- specialist audiences

Syllabus Contents:

The dissertation work will start in semester III and should preferably be a live problem in industry or an issue having a bearing on performance of the automobile industry and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. The dissertation should be presented in standard thesis format. The oral presentation as an examination shall be conducted with the help of approved external examiner

(SLC) (MAT -20002) Massive Open Online Course –I	
Teaching Scheme	**Examination Scheme**
Lecture:3 hrs/week	**End-Sem Exam - 100**

Semester IV

(SBC) (MAT-20003) Dissertation II	
Teaching Scheme	**Examination Scheme**
Practical: 18 hrs/week	End-Sem Exam –20/20/60

Course Outcomes:

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

1. critically apply the research techniques such as experimental, computational or analytical to resolve the engineering problem in automotive engineering.
2. carry out the validation of technique of his choice using existing literature.
3. analyze his own results to derive an engineering parameters as a function of governing parameters
4. present his engineering results in a generalized fashion.

Syllabus Contents:

The project work will start in semester III and will continue in the semester-IV. The problem should preferably be a live problem in industry or a micro issue having a bearing on performance of the automobile industry and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. The dissertation should be presented in standard thesis format. The oral examination shall be conducted with the help of approved external examiner

(SLC) (MAT-20004) Massive Open Online Course –II	
Teaching Scheme	**Examination Scheme**
Lecture:3 hrs/week	End-Sem Exam - 100