M. TECH – AUTOMOTIVE ENGINEERING

Department of Mechanical Engineering

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

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

CURRICULUM

First Semester

Course Code	Type	Course	L	T	P	Cr
18MA601	FC	Applied Mathematics	2	0	2	3
18AT601	FC	Automotive Chassis and Transmission Systems	3	0	0	3
18AT602	FC	Internal Combustion Engines	3	0	0	3
18AT603	FC	Automotive Materials and Manufacturing	3	0	0	3
18AT611	SC	Automotive Electronics	3	0	0	3
18AT621	FC	Internal Combustion Engines Lab	0	0	1	1
18AT622	SC	Automotive Electronics Lab	0	0	1	1
18RM600	SC	Research Methodology	2	0	0	2
18HU601	HU	Amrita Values Program*				P/F
18HU602	HU	Career Competency I*				P/F
		Credits				**19**

* Non-credit course

Second Semester

Course Code	Type	Course	L	T	P	Cr
18AT612	SC	Vehicle Dynamics	3	0	0	3
18AT613	SC	Alternate Fuels, Emissions and Control	3	0	0	3
18AT614	SC	NVH and Refinement	3	0	0	3
18AT615	SC	Modelling, Simulation and Analysis of Vehicle Systems	2	0	0	2
18AT616	SC	Hybrid Electric Vehicles	3	0	0	3
	E	Elective I	2	0	2	3
18AT623	SC	NVH Lab	0	0	1	1
18AT624	SC	Vehicle Dynamics and Simulation Lab	0	0	1	1
18HU603	HU	Career Competency II	0	0	2	1
					Credits	**20**

Third Semester

Course Code	Type	Course	L T P	Cr
	E	Elective II	3 0 0	3
	E	Elective III	3 0 0	3
18AT798	P	Dissertation		8
			Credits	**14**

Fourth Semester

Course Code	Type	Course	L T P	Cr
18AT799	P	Dissertation		12
			Credits	**12**
			Total Credits	**65**

List of Courses

Foundation Core

18MA601	FC	Applied Mathematics	2 0 2	3
18AT601	FC	Automotive Chassis and Transmission Systems	3 0 0	3
18AT602	FC	Internal Combustion Engines	3 0 0	3
18AT603	FC	Automotive Materials and Manufacturing	3 0 0	3
18AT621	FC	Internal Combustion Engines Lab	0 0 1	1

Subject Core

18AT611	SC	Automotive Electronics	3 0 0	3
18AT612	SC	Vehicle Dynamics	3 0 0	3
18RM600	SC	Research Methodology	2 0 0	2
18AT613	SC	Alternate fuels, Emissions and Control	3 0 0	3

18AT614	SC	NVH and Refinement	3 0 0	3
18AT615	SC	Modelling, Simulation and Analysis of Vehicle Systems	2 0 0	2
18AT616	SC	Hybrid Electric Vehicles	3 0 0	3
18AT622	SC	Automotive Electronics Lab	0 0 1	1
18AT623	SC	NVH Lab	0 0 1	1
18AT624	SC	Vehicle Dynamics and Simulation Lab	0 0 1	1

Elective I

Course Code	Course	L T P	Cr
18AT701	Computational Fluid Dynamics and Heat Transfer	2 0 2	3
18AT702	Finite Element Methods and Computational Tools	2 0 2	3

Electives II & III

Course Code	Course	L T P	Cr
18AT703	Testing and Validation	3 0 0	3
18AT704	Special Topics in Advanced Engineering Application	3 0 0	3
18AT705	Off-Highway Mobility	3 0 0	3
18AT706	Vehicle Body Engineering	3 0 0	3
18AT707	Automotive Safety and Lighting	3 0 0	3
18AT708	Automotive Infotronics	3 0 0	3
18AT709	New Product Development	3 0 0	3
18AT710	Automotive HVAC, Cabin Comfort and Ergonomics	3 0 0	3
18AT711	MEMS(Micro-Electro Mechanical Systems), Sensor and Technologies for Automotive Applications (Prerequisite 18AT708)	3 0 0	3
18AT712	Tribology	3 0 0	3
18AT713	Live in Lab**	3 0 0	3

Project Work

Course Code	Course	L T P	Cr
18AT798	Dissertation		8
18AT799	Dissertation		12

**Students undertaking and registering for a Live- in- lab project can be exempted from registering for an elective course in higher semester.

18MA601 APPLIED MATHEMATICS 3- 0- 0- 3

Numerical Methods: Accuracy and precision – Round-Off and Truncation errors, Taylors Series, Error propagation, Basic Applications: Interpolation and regression methods – Methods to solve nonlinear equations – Roots of equations – Numerical differentiation and integration techniques: Newton Cotes integration and Gauss Quadrature. Linear algebra: System of linear equations: Gauss elimination, Gauss Jordan, LU- Iterative methods of solution – Eigenvalues and Eigen vectors, physical meaning and methods of determining eigen values and eigen vectors. Numerical solutions of ordinary differential equations: Euler's methods and RK methods.

Linear Algebra: Review of Matrix Algebra – Vector Spaces – Sub Spaces – Linear Independence – Basis – Dimension – Null Space – Rank and Nullity – Inner Product – Orthogonality – Orthogonal Basis – Gram-Schmitt Process. Linear and inverse linear transformations.

Differential Equations:
Differential Equations: Basic definitions. Model Equations: Elliptic, Parabolic andHyperbolic PDEs. Solving PDEs Numerically - Elliptic, Parabolic and HyperbolicEquations.Finite Element Method.

TEXT BOOKS/REFERENCES:

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

18AT601 AUTOMOTIVE CHASSIS AND TRANSMISSION SYSTEMS 3- 0- 0- 3

Braking System: Principles, Components.Hydraulic Systems, Hydraulic Valves and Switches, Brake Fluid and Lines Wheel Bearings - Drum and Disc Brakes. Parking Brake System design – Analytic and understanding of brake system design-Power Brake System - Regenerative Braking

Systems, ABS Components and Operation - Electronic Stability Control Systems, Tires and Wheels - Tire Pressure Monitoring Systems - Suspension System Components and Operation, Front and rear suspension - Electronic Suspension Systems,.

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

Transmission:BasicDesign Principles – Arrangement. Passenger Car Transmissions - Manual Passenger Car - Automated Manual Transmissions - Dual Clutch Transmissions - Automatic and Hybrid Drives - Continuously Variable Transmissions. Final drives – axle drives - Differential Gears and Locking Differentials – hub drives. Gear shiftingMechanisms. Electronic Transmission Control

TEXT BOOKS/REFERENCES:

1. Naunheimer H, Bertsche B, Ryborz J and Novak W, "*Automotive Transmissions*", Springer, 2011.
2. C.R. Burrows and K.A. Edge, "*Power Transmission and Motion Control*", John Wiley and Sons, 2002.
3. Abbot and Sheldon L, "*Automotive Power Trains: Clutch, Manual Transmission, Transaxle and Final Drive*", McGraw Hill, 1988.
4. Halderman, "*Automotive Chassis Systems*", Fifth Edition, Prentice Hall, 2008.
5. Genta, Giancarlo ,Morello L, "*The Automotive Chassis Vol 1 - Component Design*"and"*The Automotive Chassis Vol 2 - System Design*", Springer, 2009.

18AT602 INTERNAL COMBUSTION ENGINES 3- 0- 0- 3

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

Combustion in Spark-Ignition Engines and Compression-Ignition Engines, Lubrication,Crevice flow, blowby, Prechamber flow, Cooling, Nature of engine heat transfer and its basic considerations, Parametric relationship of engine output with heat transfer, Convective and radiative heat transfer in engines; Heat transfer correlations in engines, Boundary layer model for in cylinder heat convection; Thermal loading and transient heat transfer through walls.

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

Simulation using appropriate tools (GT Power / Autonomie)

TEXT BOOKS/REFERENCES:

1. Heywood J B, "*Internal Combustion Engine Fundamentals*", McGraw Hill International 2017.
2. Colin Ferguson R., "*Internal Combustion Engines*", John Wiley and Sons, 2015.
3. Charles Fayette Taylor, "*The Internal Combustion Engine in Theory and Practice, Vol 1 &*2", MIT Press, 1995.
4. Carsten Baumgarten, "*Mixture Formation in IC Engines*", Springer, 2007.

18AT603 AUTOMOTIVE MATERIALS AND MANUFACTURING 3-0-0-3

Introduction to common engineering materials; metallic and non-metallic automotive materials. Materials and processes with relevance to automotive applications. Advanced materials, light weight material, nano material, synthesis and in-situ materials for automotive applications, corrosion, Standards for automotive materials.

High strength low alloy steels (HSLA), Advanced high strength steels, dual phase steels, martensitic steels etc., Advanced plastics and composites, Novel material for automotive applications, ultra-light weight material, Graphene, Battery materials and technology, case studies related to automotive applications. Case studies on crank shaft, connecting rod, piston, gear and gear box, propeller shaft.

Primary and secondary processes for automotive applications - casting, forging, heavy and sheet forming, hard and soft machining, molding, surface modification processes and Heat Treatment, Joining methods for automotive applications .Case studies on Vehicle body materials- G.I and Interstitial Free Steel processes, Power train components -Tailor Welded Blank.

Futuristic technology and material for automotive applications, Designing hybrid materials-material for auto piloting, manufacturing considerations for various lightweight automotive structures , 3D printing-materials, processes and applications. Case studies on Li-ion battery, polymer composites and sensor materials.

TEXT BOOKS/ REFERENCES:

1. Michel F Ashby, "Material Selection in Mechanical Design", Butterworth Heinemann, 2007.
2. Michel F Ashby, "Material and Design: The Art and Science of Material Selection in Product Design", Butterworth Heinemann, 2008.
3. John Mortimer, "Advanced Manufacturing in the Automotive Industry" Springer, 1997.
4. Harry Peck, "Design for Manufacturing", Pitman Publications, 1983.
5. Cantor B, Johnston, Colin Grant and Patrick, "Automotive Engineering: Lightweight, Functional and Novel Materials", Taylor & Francis Ltd, 2008.

18AT611 AUTOMOTIVE ELECTRONICS 3- 0-0-3

Introduction to Electronic systems in Automotives – Sensors and Actuators for body electronics, power train and chassis systems. Body electronics domain- Automotive alarms, Lighting, Central locking and electric windows, Climatic Control, Driver information, Parking, etc.

Power train and chassis control domain – Engine management , Transmission control, ABS, ESP, Traction Control, Active Suspension, passive safety, Adaptive Cruise Control, etc. Hardware implementation example of simple automotive systems using Sensors, Controller, Actuators etc.

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

TEXT BOOKS/REFERENCES:

1. Bosch,"*Automotive Electrics and Automotive Electronics. System and components ,Networking and Hybrid drive*", Fifth edition, Springer view 2014
2. Najamuz Zaman , " *Automotive Electronics Design Fundamental''* first edition, Springer 2015.
3. Hillier's, "*Fundamentals of Motor Vehicle Technology on Chassis and Body Electronics*", Fifth Edition, Nelson Thrones, 2007.
4. William B. Ribbens, "*Understanding Automotive Electronics*" Sixth Edition, Elsevier Newnes, 2002

18AT621 INTERNAL COMBUSTION ENGINES LAB 0-0-1-1

Disassembly and assembly of IC Engines)- Valve timing and port timing diagram- Heat balance test -Performance and emission study on SI/CI Engine using 13 mode and 8 mode test cycle, with alternative fuels, 5 mode test cycle for constant speed engines- Performance, combustion and Emission study on the effect of different fuel injection pressure and timing on the engine-Performance, combustion and emission characteristics study on the effect of preheated air and fuel. -Experiments on single and multi-cylinder SI/CI Engines to find friction power-Combustion analysis of IC engines using P-Ɵ data.

18AT622 AUTOMOTIVE ELECTRONICS LAB 0-0-1-1

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

MK40DX256 - IO Configuration, Timer, PWM- DC motor speed control, ADC, DAC, Periodic Timer Interrupt, sensor interfacing to MK40DX256 via CAN, OBD exercises using BOSCH KTS 540 kit.

18AT612 VEHICLE DYNAMICS 3- 0- 0- 3

Introduction - Acceleration - Power-Limited, traction-limited – Braking Performance- Basic Equations - Braking Forces – Brake Proportioning, efficiency-Problems. Suspensions – Ride comfort–Types and settings - Anti-Squat and Anti-Pitch Suspension prediction - Anti-Dive Suspension Geometry - Roll Center Analysis - Active Suspensions.

Steering system - The Steering Linkages and settings- Steering System Forces and Moments - Steering System Models – steering ratio, under steer/over steer-Problems. Influence of Front-Wheel Drive - Four-Wheel Steer. Rollover - Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, transient Rollover. Tires – Construction - Size and Load Rating - Tractive and cornering Properties - Camber Thrust - Aligning Moment - Combined Braking and Corning - Conicity and Ply Steer - Tire Vibrations. Ride – Excitation sources - Vehicle Response Properties - Steady-State cornering – low speed turning and High speed cornering-problems. Suspension Effects on Cornering. Models for predicting corner forces. Design of Modern wheel and tyre characteristics and their influence on vehicle behaviour. Longitudinal and lateral Vehicle dynamics and control-Problems.

Aerodynamic forces on ground vehicles - Wheel load - traction due to Aerodynamic forces - safety, performance characteristics –Problems-Three dimensional effects - Design features to reduce drag. This module will introduce the student to computational analysis and kinematic and force analysis of systems with appropriate software.

Appropriate ADAMS models to be developed for Multibody Dynamics study.

TEXT BOOKS/REFERENCES:

1. Thomas D.Gillespie, "*Fundamentals of Vehicle Dynamics*", SAE International Publication, 2005.
2. Popp, Karl, Schiehlen and Werner, "*Ground Vehicle Dynamics*", Springer Publication, 2010.
3. Rao V.Dukkipati and Jian Pang, "*Road Vehicle Dynamics*", SAE International Publication, 2008.
4. Richard Barnard, "*Road Vehicle Aerodynamic Design*", Second Revised Edition, Mechaero Publishing, 2001.

18AT613 ALTERNATE FUELS, EMISSIONS AND CONTROL 3- 0- 0- 3

Emission and its environmental impact -Exhaust emissions -Pollutant formation and chemistry-Nitrogen Oxides, Carbon Monoxide, Unburned Hydrocarbon, soot formation –Emissionformation in CI and SI engines-Other emissions – Particulate, Crankcase, Evaporative, Refueling, non regulated emissions- Fuel Options for Controlling Emissions -Alternate fuels-Alcohols and ethers-Bio-fuels, Synthetic fuels–Indian drive cycle- European test cycle-EmissionStandards.

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

Combustion Diagnostic Emission Control for Euro VI Technology - Emission Standards forInspection and Maintenance Programs - Remote Sensing of Vehicle Emissions: OperatingPrinciples, Capabilities, and Limitations.Future trends.

TEXT BOOKS/REFERENCES:

1. Colin Ferguson R., "*Internal Combustion Engines*", John Wiley and Sons, 2015.
2. AsifFaiz, Christopher and S.Weaver, "*Air Pollution from Motor Vehicles: Standards and Technologies for Controlling Emissions*" World Bank Publication, 2000.
3. Heywood J B, "*Internal Combustion Engine Fundamentals*", McGraw Hill International, 2017.
4. B.P.Pundir,"*IC Engines: Combustion and Emissions*", Alpha Science International Limited, 2010

18AT614 NVH AND REFINEMENT 3- 0- 0-3

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

Fourier series – Fourier Integrals –- Discrete Fourier Transforms – Fourier and Laplace Transforms - Filters - Windowing - Uncertainty principle – Time Sampling and Aliasing - Random signal processing and analysis -Theory of modal analysis - Methods for performing modal analysis.

Vehicle NVH refinement –Vehicle Development process - target setting and Benchmarking– Simulation and Experimental techniques in NVH refinement - Refinement of Power train systems – Aerodynamic noise and its refinement - Mid– and high-frequency problems – Statistical Energy Analysis-Acoustic shielding and sound packages-Active noise control and their applications.

TEXT BOOKS/REFERENCES:

1. Xu Wang, "*Vehicle Noise and Vibration Refinement*", CRC Press Publication, 2010.
2. J.M. KrodkiewskI, "*Mechanical Vibration*" Univ of Melbourne, 2008
3. Kihong Shin and Joseph K. Hammond "*Fundamentals of Signal Processing for Sound and Vibration Engineers*", John Wiley, 2008.

18AT615 MODELLING, SIMULATION AND ANALYSIS OF VEHICLE SYSTEMS DESIGN 2-0-0-2

Fundamental Concepts in Mathematical Modelling

Abstraction – linearity and superposition – balance and conservation laws and the system – boundary approach. **Lumped – Element Modeling-**Mechanical systems-Translational, rotational. Hydraulic systems.Thermal systems.RLC Electrical Systems.

Modeling of First–order and Second–order Systems

Governing equations for free and forced responses – transient response specifications – experimentaldetermination – Laplace transform. **Feedback systems-**Systems with feedback – block diagrams – properties of feedback systems – relative stability-phase and gain margins.

Systems Engineering and Application
Fundamentals of systems engineering, Systems engineering process, Requirement and functional analysis of systems. Application of systems engineering: requirements to design concepts. Understanding systems engineering through case studies.

TEXT BOOKS/REFERENCES:

1. Philip D Cha, James J Rosenberg and Clive L Dym, '*Fundamentals of Modeling and Analyzing EngineeringSystems"*, Cambridge University, 2000.
2. Woods, Robert L., and Lawrence Kent L, "*Modeling and Simulation of Dynamic Systems*", Prentice Hall,1997.
3. Amalendu Mukherjee, RanjitKarmakar, "*Modeling and Simulation of engineering Systems through Bondgraphs*", Narosa, 2000.
4. Close Frederick, "*Modeling and Analysis of Dynamic Systems*", Wiley, 2003 edition
5. *INCOSE Systems Engineering Handbook,* John wiley and sons .2015

18AT616 HYBRID ELECTRIC VEHICLES 3–0–0–3

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.Electric Drive-trains and 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 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 internalcombustion engine , Sizing the propulsion motor, sizing the powerelectronics, 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.

TEXT BOOKS/REFERENCES:

1. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*", CRC Press, 2003.
2. MehrdadEhsani, YimiGao, Sebastian Longo, KambizEbrahimi, "*Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design"*, CRC Press, Third edition
3. James Larminie, John Lowry, "*Electric Vehicle Technology*" Wiley, second ediion.2012.
4. SandeepDhameja, "*Electric Vehicle Battery Systems*", Newnes, 2001

18AT623 NVH LAB 0-0-1-1

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

18AT624 VEHICLE DYNAMICS AND SIMULATION LAB 0- 0- 1- 1

Homologation trials - Acceleration test, Brake test, Single lane change test, Double lane change test.

Steering effort test.- Steering torque measurement- Brake force measurement test- Gear shift effort test.

Pitch, Yaw and roll measurement- Steering robot demonstration.

Simulated Vehicle performance on road profile-creating and customizing the vehicle model to the requirement-Exercises using simulation tools

18RM600 RESEARCH METHODOLOGY 2-0-0-2

Unit I:

Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach, Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of reasoning in research.

Unit II:

Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:

Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:

Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V:

Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science

TEXT BOOKS/ REFERENCES:

1. Bordens, K. S. and Abbott, B. B., “Research Design and Methods – A Process Approach”, 8th Edition, McGraw-Hill, 2011
2. C. R. Kothari, “Research Methodology – Methods and Techniques”, 2nd Edition, New Age International Publishers
3. Davis, M., Davis K., and Dunagan M., “Scientific Papers and Presentations”, 3rd Edition, Elsevier Inc.
4. Michael P. Marder,“ Research Methods for Science”, Cambridge University Press, 2011
5. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”. Aspen Law & Business; 6 edition July 2012

18AT701 COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER 2-0-2-3

Mathematical description of fluid flow and heat transfer-Conservation equations for mass, momentum, energy and chemical species-Classification of partial differential equations

Discretization techniques using finite difference and finite volume formulations, Direct & Iterative Techniques or solving Discretized Equations - TDMA,

Formulations for Convection-Diffusion problems, Upwinding, Explicit, Semi-implicit and Fully-Implicit formulations for unsteady problems, Stability analysis, Irregular geometries and body-fitted coordinate system.Introduction to Turbulence Modeling, Applications to practical problems.

TEXT BOOKS/REFERENCES:

1. Versteeg, H.K., and Malalasekara, W, *"An Introduction to Computational Fluid Dynamics"*, The Finite Volume Method, 2007
2. Patankar, S.V., "*Numerical Heat Transfer and Fluid Flow"*, Hemisphere Publishing Corporation, 1980.
3. Anderson, D.A., Tannehill J.C., and Pletcher, R.H., *"Computational Fluid Mechanics and Heat Transfer*", Hemisphere Publishing Corporation, 1984

18AT702 FINITE ELEMENT METHODS AND COMPUTATIONAL TOOLS 2-0-2-3

Fundamentals of governing equations in Solid Mechanics and Heat Transfer. Basic finite element procedures: Direct Stiffness Method, Principle of Minimum Potential Energy, Strong form, Weak form, Variational formulation, Weighted Residual Method - Galerkin formulation, Formulation of the finite element equations - Element types - Basic and higher order elements –1D, 2D, 3D coordinate systems. Finite elements in Solid Mechanics: Analysis of trusses, beams and frames, Plane stress, Plane strain and Axisymmetric elements. Isoparametric formulation.

Finite elements in Heat Transfer: Formulations and solution procedures in 1D and 2D problems. Structural Dynamics: Formulation - Element mass matrices - Evaluation of Eigen values and Eigen vectors - Natural frequencies and mode shapes - Numerical time integration. Computer implementation of the Finite element method: Pre-processing, Element calculation, Equation assembly – Assembly Flowchart, ID, IEN, LM arrays, Solving – Numerical Integration – Gaussian Quadrature, Post processing – Primary and Secondary variables.

TEXT BOOKS/REFERENCES:

1. Thomas J. R. Hughes, "*The Finite Element Method – Linear Static and Dynamic Finite Element Analysis*", Dover Publications Inc, 2000.
2. Rao S. S., "*The Finite Element Method in Engineering*", Fourth Edition, Elsevier, 2007.
3. Daryl L. Logan, "*A First Course in the Finite Element Method*", Fourth Edition, Cengage Learning, 2007.
4. David V. Hutton, "*Fundamentals of Finite Element Analysis*", McGraw Hill, 2005.
5. Reddy J. N., "*An Introduction to the Mathematical Theory of Finite Elements*", Dover Publications, 2011.

18AT703 TESTING AND VALIDATION 3-0-0-3

Need for testing and validation –vehicle development process - Types of testing –Objectives of testing- Measurement of Real world usage patterns and their analysis – design of test specifications-Engine testing – Definitions and calculations – Instrumentation – Services - Types of engine tests – Transient and chassis dynamometer tests - Emissions and their measurement – Emission legislation – TAPS document

Vehicle tests –Tests on components and systems – Instrumentation and Transducers – EMI/EMC testing and regulations-Safety and crash testing and Regulations -Materials and material testing-Servo-hydraulics and fatigue testing- CMVR – Indian and Automotive Industry standards – International standards and WP 29

Virtual product development and computer aided engineering – virtual testing - Road to lab to desktop-Design of experiments – Basic concepts - application of statistics – Analysis of variance - factorial testing –Fractional factorial testing - Taguchi methods.

TEXT BOOKS/REFERENCES:

1. Martyr and Plint, "*Engine Testing – Theory and Practice*", Butterworth Heinemann, 2007.
2. Douglas Montgomery, "*Design and Analysis of Experiments*", John Wiley, 2008.
3. Jiju Antony, "*Design of Experiments*" Butterworth & Heinemann, 2003.
4. Hinkleman and Kempthone, "*Design and Analysis of Experiments – Advanced Experimental Design*", John Wiley& Sons, 2005

18AT704 SPECIAL TOPICS IN ADVANCED ENGINEERING APPLICATION 3-0-0-3

- Light weighting for electric vehicles
- Green engine technology.
- Battery management systems.
- Hybrid Technology
- Tribology of Automotive Components
- Additive Manufacturing for Automotive Applications.
- Electrocoating for automotive applications.
- Connected cars-Requirements &Technical feasibility.
- Advancement in onboard diagnostics.
- Autotronics and Vehicle Intelligence.

- Visco-Elastic Materials and Vibration Control
- Flow-Induced Noise and Vibration Sources in Automotive systems.
- Surface Coatings for Automotive Applications.

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

18AT705 OFF-HIGHWAY MOBILITY 3- 0- 0- 3

Study of morphology, operational characteristics, and design considerations of off-road vehicles used in the agriculture, infrastructure and construction. Traction and Tractor Performance. Tractor, harvester, windrowers: engine performance and design, vehicle testing, turbo chargers and intercoolers, drive trains, chassis mechanics, hydraulic systems including PTO. Tractor Test procedure –Nebraska Test. Emission norms and legislative requirement for off highway vehicles

Introduction to Terramechanics and Off-road vehicle Engineering. Role and measurement and modelling of Terrain Behaviour. Methods for Evaluating Tracked Vehicle Performance. Design of Mechanical and Hydraulic dredges – backhoe, tracked excavator, pick and carry crane, soil compactor. A brief introduction to the Mechatronics and Intelligent systems for Off-road Vehicles.

TEXT BOOKS/REFERENCES:

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

18AT706 VEHICLE BODY ENGINEERING 3-0-0-3

CAR BODY DETAILS: Types: compact, hatch-back,saloon, convertibles, limousine, estate car, racing and sports car. Car body construction; design criteria, prototype making, Body In white, creating the inner panels, underfloor panels, detailing of class A surfaces (Flanges, seatings, hemming) from manufacturing point of view.

BUS BODY DETAILS: Types: mini bus, single decker, double-decker, two level and articulated bus. Bus body layout; floor height, engine location, entrance and exit location, seating dimensions.

Constructional details: frame construction, double skin construction, types of metal sections used, Conventional and integral type construction, Bus Body Code and Regulations

COMMERCIAL VEHICLE DETAILS: Types of body; flat platform, drop side, fixed side, tipper body, tanker body, Light commercial vehicle body types. Dimensions of driver's seat relation to controls.Driver's cab design.

BODY MATERIALS, TRIM AND MECHANISMS: Steel sheet, timber, plastic, GRP, properties of materials; Corrosion, anticorrosion methods. Selection of paint and painting process.Body trim items.Body mechanisms.

Mechanism analysis using software – max.of 3 hours of class,

TEXT BOOKS/REFERENCES:

1. J.Powloski "*Vehicle Body Engineering*" Business Books Ltd, London, 1989
2. GilesJ.C., "*Body Construction and Design*" Liiffe Books Butterworth & Co, 1971.
3. John Fenton, "*Vehicle Body Layout and Analysis*" Mechanical Engineering Publication Ltd., 1982.
4. BraithwaiteJ.B, "*Vehicle Body Building and Drawing*" Heinemann Educational Books Ltd., London, 1977.
5. Lorenzo Morello, Lorenzo Rosti Rossini, Giuseppe Pia, Andrea Tonoli "*The Automotive Body* , Volume 1 Components Design, volume 2 : System Design " Springer science ,2011

18AT707 AUTOMOTIVE SAFETY AND LIGHTING 3- 0- 0- 3

Statistics of accidents - Accident investigation and analysis-.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, Optimization of vehicle structures for crashworthiness, Types of impacts, and Impact with rebound, movable barrier tests, Roll over crash tests, Side and Frontal Pole Impact-Behavior of specific body structures in crash testing, Regulatory requirements for crash testing-National and international Regulations, test requirements and testing procedure

Pedestrian Impact-Pedestrian Safety and Ergonomics - Anthropometry - Locations of controls-Human impact tolerance- Determination of Injury thresholds, Severity Index, Study of comparative tolerance, Injury criteria's and relation with crash and modeling and simulation studies in dummy. Vehicle Safety systems - Survival space requirements, Restraint systems used in automobiles -safety belts, Head restraints, Air bags .

Use of energy absorbing systems - Impact protection from steering controls. Design of seats - Damageability criteria in bumper designs - safety glass and their requirements, rearward field of vision in automobiles - Warning devices- under run protection devices-Collision warning and avoidance systems- Sensors. Comfort and convenient systems. Automotive Lighting and Light Signalling Devices.

TEXT BOOKS/REFERENCES:

1. Johnson W and Mamalis A.G., "*Crashworthiness of Vehicles*", Mechanical Engineering Publications, 2002.
2. Daniel J Helt, "*Recent Development in Automotive Safety Technology*", SAE International Publication, 2009.
3. Robert Bosch, "*Safety Comfort and Convenience Systems*", Wiley, 2008.
4. Matthew Huang, "Vehicle Crash Mechanics".
5. Rollover Prevention, Crash Avoidance, Crashworthiness, Ergonomics and Human Factors", SAE Special Publication, November 2003.

18AT708 AUTOMOTIVE INFOTRONICS 3-0-0-3

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

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

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

TEXT BOOKS/REFERENCES:

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

18AT709 NEW PRODUCT DEVELOPMENT 3- 0- 0- 3

Concept & Ideation: Styling concept creation, realistic rendering with car paints/textures. Translating the cloud of points of clay model into surfaces with reverse engineering. Class A surface creation – refining the styling surfaces to make them Class A surfaces with manufacturability.

New product development – different steps in NPD, VOC/QFD, Product and brand strategy. Packaging, market research and its influence .New products as projects.Design theory and

methodology - innovation methodologies - Eco-design - User centered design Organisational structures and cross functional teams. Marketing and R & D interfaces.

Concept - context and role of managing uncertainty – Role of individual in innovation process. Innovation and operation management – Managing intellectual property – Managing technology and knowledge.Strategic alliances and network, R&D projects, Technology transfer in innovation.

TEXT BOOKS/REFERENCES:

1. Paul Trott, "*Innovation Management and New Product Development*", Fourth Edition, Prentice Hall, 2008.
2. Wiley-Blackwell, "*The Journal of Product Innovation Management*", 2010.
3. World Scientific Journals, "*International Journal of Innovation Management*", 2011

18AT710 AUTOMOTIVE HVAC, CABIN COMFORT AND ERGONOMICS 3- 0- 0- 3

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

Applications of HVAC fundamentals to analysis and design of automotive air conditioning systems. Psychometrics, passenger thermal comfort, refrigeration cycles and system design, central and Unitary systems, heating system design, air flow circuits, Air cleaning, ventilation, air space diffusion, compact heat exchanger design, controls and instrumentation. Cabin comfort- In-car air conditioning - overall energy efficiency - air management.

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

TEXT BOOKS/REFERENCES:

1. Boyce Dwiggins, "*Automotive Air Conditioning*", Delmar Cengage Learning, 2001.
2. Steven Daly, "*Automotive Air Conditioning and Climate Control Systems*", Butterworth Heinemann, 2006.
3. John Haynes, "*Automotive Heating and Air Conditioning Systems Manual*", Haynes Publications, 2000.
4. ASHRAE Handbooks.
5. B.Peacock, WaldemarKarwowski; "*Automobile ergonomics*." Publisher: CRC; 1 edition, 1993

18AT711 MEMS (MICRO-ELECTRO-MECHANICAL SYSTEMS), 3- 0- 0- 3

SENSORS AND TECHNOLOGIES FOR AUTOMOTIVE APPLICATIONS

(Prerequisite 18AT708)

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

Transduction mechanisms and modeling in different energy domains.Analysis of micromachined capacitive, piezoresistive, and thermal sensors/actuators and applications.

Computer-aided design for MEMS layout, fabrication, and analysis. MEMS for automotive applications.Different type of sensors and actuators. Control systems for various applications.

TEXT BOOKS/REFERENCES:

1. Tai-Ran Hsu, "*MEMS and Microsystems Design and Manufacturing*" Tata McGraw Hill, 2002.
2. Mohammed Gad-el-Hak, "*The MEMS Handbook*", Second Edition, CRC Press, 2005.
3. Ville Kaajakari "*Practical MEMS: Design of Microsystems, Accelerometers, Gyroscopes, RF MEMS, Optical MEMS, and Microfluidic Systems*", Small Gear Publishing, 2009.
4. Proceedings of the International Forum on Advanced Microsystems for Automotive Applications (AMAA), Germany, 2010.

18AT712 TRIBOLOGY 3- 0- 0- 3

Tribological considerations in design of gears, cams, reciprocating components, Engine tribology, transmission drive line-transmission, traction drive, universal and constant velocity joints, wheel bearings, drive chains, lubrication regimes in the engine. Friction and Wear - surface properties, surface parameters and measurements, sliding friction, rolling friction, modified adhesive theory, engine friction, losses and engine design parameters- mechanism of wear, wear testing and methods of wear measurements.

Bearings, Lubrication and Automotive Lubricants - hydrodynamics, generalized Reynold's equation & physical significance of terms, pressure distribution and load carrying capacity equations for hydrodynamic journal bearing- thrust bearings, Raleigh bearing sintered bearings.

Automotive Lubricants and additives- Type of lubricants, properties and testing, service, classification of lubricants, lubrication of tribologicalcomponentsstandard tests, engine oil performance designations, transmission fluids, gear,axle,solid, EP lubricants, ferrography and other rapid testing methods of lubricant contamination Hydrostatic bearings, bearing pad coefficients, squeeze film lubrication Elastohydrodynamic Lubrication, rolling of two cylinders, fatigue and diagnosis.

Road tyre contacts, hydroplaning. Preventive Maintenance - schedule, Noise, wear, corrosive maintenance. Signature analysis of Bearings and Gears, real time condition monitoring using vibration analysis - Periodic Maintenance - Maintenance of batteries, Maintenance of auxiliaries Lubrication system, lubrication charts , Cooling system Maintenance, Maintenance of Electrical

system, testing of starters, alternators, ignition coils, wiring harness, horns, wipers, maintenance of drive line system.

TEXT BOOKS/REFERENCES:

1. Halling J., "*Principles of Tribology*", McMillan Press Ltd, 2000.
2. Neale M. J. "*Tribology Hand Book*", Butterworth Heinemann, 2002.
3. Fuller D. D., "*Theory and Practice of Lubrication for Engineers*", John Wiley, 2004.
4. Nakra B.C., "*Theory & Practice of Mechanical Vibrations*", McGraw Hill, 1998.