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
16MA601	FC	Numerical Methods, Linear Algebra and Differential Equations	3	0	0	3
16AT601	FC	Automotive Chassis and Transmission Systems	3	0	0	3
16AT602	FC	Internal Combustion Engines	3	0	0	3
16AT603	FC	Automotive Materials and Manufacturing Techniques	3	0	0	3
16AT611	SC	Vehicle Dynamics	3	0	0	3
16AT621	SC	FEA/Computational Tools Lab	0	0	1	1
16AT622	SC	Vehicle Simulation lab	0	0	1	1
16AT623	FC	IC Engines Laboratory	0	0	1	1
16AT624	SC	Programming Using MATLAB	0	0	1	1
16HU601	HU	Cultural Education *				P/F
*Non Credit Course			**Credits**			**19**

Second Semester

Course Code	Type	Course	L	T	P	Cr
16AT612	SC	Automotive Electronics	3	0	0	3
16AT613	SC	Automotive Emissions and Control	3	0	0	3
16AT614	SC	NVH and Refinement	3	0	0	3
16AT615	SC	Computational Fluid Dynamics and Heat Transfer	1	0	1	2
	E	Elective I	3	0	0	3
	E	Elective II	3	0	0	3
16AT625	SC	NVH Lab	0	0	1	1
16AT626	SC	Automotive Electronics Lab	0	0	1	1
16EN600	HU	Technical Writing*				P/F

*Non Credit Course	Credits	19

Third Semester

Course Code	Type	Course	L T P	Cr
16AT616	SC	Modelling, Simulation and Analysis of Vehicle Systems Design	3 0 0	3
	E	Elective III	3 0 0	3
16AT798	P	Dissertation		10
			Credits	**16**

Fourth Semester

Course Code	Type	Course	L T P	Cr
16AT799	P	Dissertation		12
			Credits	**12**

Total Credits 66

List of Courses

Foundation Core

16MA601	FC	Numerical Methods, Linear Algebra and Differential Equations	3 0 0	3
16AT601	FC	Automotive Chassis and Transmission Systems	3 0 0	3
16AT602	FC	Internal Combustion Engines	3 0 0	3
16AT603	FC	Automotive Materials and Manufacturing Techniques	3 0 0	3
16AT623	FC	IC Engines Laboratory	0 0 1	1

Subject Core

16AT611	SC	Vehicle Dynamics	3 0 0	3

16AT621	SC	FEA/ Computational Tools Lab	0 0 1	1
16AT622	SC	Vehicle Simulation lab	0 0 1	1
16AT624	SC	Programming Using MATLAB	0 0 1	1
16AT612	SC	Automotive Electronics	3 0 0	3
16AT613	SC	Automotive Emissions and Control	3 0 0	3
16AT614	SC	NVH and Refinement	3 0 0	3
16AT615	SC	Computational Fluid Dynamics and Heat Transfer	1 0 1	2
16AT625	SC	NVH Lab	0 0 1	1
16AT626	SC	Automotive Electronics Lab	0 0 1	1
16AT616	SC	Modelling, Simulation and Analysis of Vehicle Systems Design	3 0 0	3

Electives

Course Code	**Course**	**L T P**	**Cr**
	Elective		
16AT701	Hybrid Electric Vehicles	3 0 0	3
16AT702	Special Topics in Advanced Engineering Application	3 0 0	3
16AT703	Design for Manufacturing, Assembly and Environment	3 0 0	3
16AT704	Vehicle Body Engineering	3 0 0	3
16AT705	Automotive Safety	3 0 0	3
16AT706	Automotive Infotronics (Prerequisite 16AT612)	3 0 0	3
16AT707	New Product Development	3 0 0	3
16AT708	Automotive HVAC, Cabin Comfort and Ergonomics	3 0 0	3
16AT709	MEMS(Micro-Electro Mechanical Systems), Sensor and Technologies for Automotive Applications (Prerequisite AT 706)	3 0 0	3
16AT710	Off-Highway Mobility	3 0 0	3
16AT711	Testing and Validation	3 0 0	3
16AT712	Tribology	3 0 0	3

Project Work

Course Code	Course	L T P	Cr
16AT798	Dissertation		10
16AT799	Dissertation		12

16MA601 NUMERICAL METHODS, LINEAR ALGEBRA

AND DIFFERENTIAL EQUATIONS 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*", Fifth Edition, New Age International Publishers, 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, Tenth Edition, John Wiley and Sons, 2015.

16AT601 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, 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 shifting Mechanisms. Electronic Transmission Control – Networked and Control Systems,Vehicle Performance.

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 and Morello L, "*The Automotive Chassis Vol 1 - Component Design*"and"*The Automotive Chassis Vol 2 - System Design*", Springer, 2009.

16AT602 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 incylinder heat convection; Thermal loading and transient heat transfer through walls.

Hybrid engines, Multifuel engines - Reciprocating Piston engine with External Combustion, Stirling engine - Wankel rotary engine, Gas turbine.-Simulation using appropriate tools

TEXT BOOKS/REFERENCES:

1. Heywood J B, "*Internal Combustion Engine Fundamentals*", McGraw Hill International, 1993.
2. Colin Ferguson R., "*Internal Combustion Engines*", John Wiley and Sons, 1989.
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.

16AT603 AUTOMOTIVE MATERIALS AND MANUFACTURING TECHNIQUES

3-0-0-3

Material selection in Mechanical design.Engineering materials such as Steel, Aluminium, Plastics, rubber, polymer and composites and their properties.Processes and process selection - selection of materials with relevance to automotive applications.Designing hybrid materials.Material groups, Material standards, Properties of Metallic and Non Metallic automotive materials, Corrosion and its protection.

Advanced materials - High strength low alloy steels (HSLA). Advanced high strength steels, dual phase steels, mortensitic steels etc.Advanced plastics and composites, Nano materials, bio based materials. Battery materials and technology.Principles, analytical formulation and applications of surface modification processes.

Materials processing and design. Manufacturing processes, including casting, forging, forming, machining and molding for the automotive industry. Process Chains for Steel Part Processing - Soft Machining Methods - Heat Treatment Methods - Hard Machining Methods. Process Chains

for Cast Part Processing - Casting Methods - Machining Cast Parts - Process Chains for Gear Machining.

Process Chains for Sheet Metal Machining - Sheet Separation - Sheet Forming - Manufacturing of Polymer/Composite components for automotive applications. Joining methods - welding, fasteners, adhesives, etc.Manufacturing considerations for various lightweight automotive structural materials.Methods of producing lightweight automotive structures.

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.

16AT611 VEHICLE DYNAMICS 3- 0- 0-3

Introduction - Acceleration - Power-Limited, traction-limited – Braking Performance- Basic Equations - Braking Forces – Brake Proportioning, efficiency. Suspensions - Solid Axles - Independent Suspensions - Anti-Squat and Anti-Pitch Suspension - Anti-Dive Suspension Geometry - Roll Center Analysis - Active Suspensions.

Steering system - The Steering Linkages - Steering System Forces and Moments - Steering System Models – steering ratio, under steer/over steer, 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 - Suspension Effects on Cornering. Design of Modern wheel and tyre characteristics and their influence on vehicle behaviour.Longitudinal and lateral Vehicle dynamics and control.

Aerodynamic forces on ground vehicles - Wheel load - traction due to Aerodynamic forces - safety, performance characteristics - 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 or IPG car maker exercise development for various topics.

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. RaoV.Dukkipati and Jian Pang, "*Road Vehicle Dynamics*", SAE International Publication, 2008.
4. Richard Barnard, "*Road Vehicle Aerodynamic Design*", Second Revised Edition, Mechaero Publishing, 2001.

16AT621 FEA/ COMPUTATIONAL TOOLS LAB 0- 0- 1- 1

Introduction to FEM,Newton's method of solution, Solution convergence, Mesh convergence, etc.

Static Analysis: simple load-deflection, Contact mechanics, Stress concentration, Large deflection problems-Punching, rolling etc.,

Dynamic Analysis: Impact problems, Crash analysis

Coupled Physics: Thermo mechanical coupled problems

16AT622 VEHICLE SIMULATION LAB 0-0-1-1

Vehicle Testing Procedure-Simulated Vehicle performance on road profile-creating and customizing the vehicle model to the requirement-Impact of broad performance influencing parameters such as aerodynamics drag, vehicle layout, Tyre inflation etc.. Adding addition module such as ABS/ESP and studying its performance, Standards, Exercises using simulation tools.

16AT623 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 with alternative fuels- 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- data.

16AT624 PROGRAMMING USING MATLAB 0-0-1-1

Variables and constants, operators and simple calculations -Formulas and functions

Matrices and vectors-Matrix and linear algebra review-Vectors and matrices in MATLAB-Matrix operations and functions in MATLAB -Introduction to Arrays- Graphing Functions Using MATLAB- Graphing Exercises

Numerical simulations-Numerical methods and simulations-Random number generation-Numerical simulation exercises.

16AT612 AUTOMOTIVE ELECTRONICS 3- 0-0-3

Current, voltage, passive elements (resistance, inductance, capacitance)- Ohm law, Kirchhoff s laws - dc circuits and ac circuits. Machines - construction and principle of operation- types of dc machines: Shunt, series, compound- and their operating characteristics- starting and speed control - PN junction diode: construction- operating characteristics- circuits using diodes: rectifiers, clippers, clampers-zener diode. Bipolar junction transistor: construction- operating characteristics, biasing circuits, applications – Field Effect Transistor, MOS Field Effect Transistor: construction and working-Operational amplifiers: Ideal op-amp characteristics, Inverting and Non-inverting amplifier, op-amp applications: Adder,subtractor, integrator, differentiator, comparator, zero crossing detector.

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, HVAC Vehicle immobilization & deactivation, 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. Jack E K, Steven M D and William H H, "*Engineering Circuit Analysis*", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.
2. Nagrath I J and Kothari D P, "*Electric Machines*", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.
3. Boylested, "*Electronic Devices and Integrated Circuits*", PHI, 1997.
4. Hillier's, "*Fundamentals of Motor Vehicle Technology on Chassis and Body Electronics*", Fifth Edition, Nelson Thrones, 2007.
5. William B. Ribbens, "*Understanding Automotive Electronics*" Sixth Edition, Elsevier Newnes, 2002.

16AT613 AUTOMOTIVE 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 –.Emission formation in CI and SI engines-Other emissions – Particulate, Crankcase, Evaporative, Refueling - Fuel Options for Controlling Emissions –Indian drive cycle- European test cycle-Emission Standards.

Emissions Measurement and Testing Procedures of two/three wheelers, light duty vehicles and Heavy-duty Vehicle Engines, Vehicle Emission Factors. In-use vehicles emission testing-Technology for Controlling Emissions for SI & CI Engine - Exhaust Gas Treatment, Catalytic Converters, Thermal Reactors, Particulate Traps, SCR/SNR Technology

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

TEXT BOOKS/REFERENCES:

1. Colin Ferguson R., "*Internal Combustion Engines*", John Wiley and Sons, 1989.
2. B.P.Pundir,"*IC Engines: Combustion and Emissions*", Alpha Science International Limited, 2010.
3. Asif Faiz, Christopher and S.Weaver, "*Air Pollution from Motor Vehicles: Standards and Technologies for Controlling Emissions*" World Bank Publication, 2000.
4. Heywood J B, "*Internal Combustion Engine Fundamentals*", McGraw Hill International, 1993.

16AT614 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.

16AT615 COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER 1-0-1-2

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.

16AT625 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, Demostration of inverse square law, Demonstration of the efeect 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 anlaysis - Jury Rating, Metrics and its correlation

16AT626 AUTOMOTIVE ELECTRONICS LAB 0-0-1-1

KCL and KVL Verification – Voltage and Current Divider Circuit – RLC circuit(MATLAB simulation) – RC Low Pass Filter – OPAmp Circuits – Inverting and Non – Inverting amplifiers – Adder – PID controller (MATLAB simulation)

MK40DX256 - IO Configuration, Timer, PWM, ADC, DAC, Periodic Timer Interrupt

TEXT BOOKS/REFERENCES:

1. Jack E K, Steven M D and William H H, "*Engineering Circuit Analysis*", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.

2. MK40DX256 reference manual

16EN 600 TECHNICAL WRITING P/F
(Non-credit Course)

Technical terms – Definitions – extended definitions – grammar checks – error detection – punctuation – spelling and number rules – tone and style – pre-writing techniques – Online and offline library resources – citing references – plagiarism – Graphical representation – documentation styles – instruction manuals – information brochures – research papers – proposals – reports (dissertation, project reports etc.)

TEXTBOOKS/REFERENCES:

1. H.L. Hirsch, *Essential Communication Strategies for Scientists, Engineers and Technology Professionals*, Second Edition, New York: IEEE Press, 2002.
2. P.V. Anderson, *Technical Communication: A Reader-Centered Approach,* Sixth Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2008, (Reprint 2010).
3. W.Jr. Strunk and E.B.White, *The Elements of Style*, New York. Alliyan & Bacon, 1999.

16AT616 MODELLING, SIMULATION ANDANALYSIS OF VEHICLE SYSTEMS DESIGN 3-0-0-3

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.Thermalsystems.RLC Electrical Systems.

Modeling of First–order and Second–order Systems

Governing equations for free and forced responses – transient response specifications – experimental

determination – 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 Engineering Systems"*, Cambridge University, 2000.
2. Woods, Robert L. and Lawrence Kent L, "*Modeling and Simulation of Dynamic Systems*", Prentice Hall,1997.
3. Amalendu Mukherjee and Ranjit Karmakar, "*Modeling and Simulation of Engineering Systems Through Bondgraphs*", Narosa, 2000.
4. Close Frederick, "*Modeling and Analysis of Dynamic Systems*", Third Edition, Wiley, 2001.
5. *INCOSE Systems Engineering Handbook*

16AT701 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. 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 (BEV).

TEXT BOOKS / REFERENCES:

1. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*", CRC Press, 2003.

2. MehrdadEhsani, YimiGao, Sebastian E. Gay and Ali Emadi, "*Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design"*, CRC Press, 2004.

3. James Larmini and John Lowry, "*Electric Vehicle Technology*" Wiley, 2003.

4.Sandeep Dhameja, "*Electric Vehicle Battery Systems*", Newnes, 2001.

16AT702 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.

16AT703 DESIGN FOR MANUFACTURING, ASSEMBLY AND ENVIRONMENT 3-0-0- 3

Introduction to DFMA concepts - general guidelines - advantages of DFMA. Poka Yoke methods.Selection of Materials and Processes – Product Design for Manual assembly – Electrical connections and wire harness assembly – Design for high speed automatic and robot assembly.

Design for Machining, injection moulding, sheet metal working, die-casting, Powder metal casting, sand casting, Investment casting, Hot forging –Design for manufacture and computer aided design. Design for serviceability and sustainability and environment. Assembly on product and process.Assemblyrepresentation.Assembly sequence.

Datum flow chain.Geometric Dimensioning &Tolerencing.Toleranceanalysis.Tolerancesynthesis.Robustdesign.Fixturing.Joint design and joining methods.Stream of variation.Auto body assembly case studies and Laboratory exercises. Advantages and challenges in using LCA-basedenvironmental impact assessment for guiding designdecisions.

TEXT BOOKS/REFERENCES:

1. Corrado Poli, "*Design for Manufacturing: A Structured Approach*", Butterworth-Heinemann, 2001.
2. David M. Anderson, "*Design for Manufacturability & Concurrent Engineering*", CIM Press, 2004.
3. Dr. David M. Anderson et al. "*How to Design for Low Cost, Design in High Quality, Design for Lean Manufacture, and Design Quickly for Fast Production*", CIM Publication, 2010.
4. Nikhil Joshi, Stueti Gupta, YatinJayawant,Goutam Mohapatra and Satyam S. Sahay, - "*Advantages and Challenges in Using LCA-based Environmental Impact Assessment for Guiding Design Decisions"*, Int. J. Sustainable Design, Vol. 2, No. 2, 2013.
5. Geoffrey Boothroyd, Winston Knight and Peter Dewhurst, "*Product Design for Manufacture & Assembly Revised & Expanded*", Second Edition, CRC Press, 2001.

16AT704 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. Giles J.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.

16AT705 AUTOMOTIVE SAFETY 3- 0- 0- 3

Statistics of accidents - Accident investigation and analysis.Active and passive safety. Characteristics of vehicle structures, Optimization of vehicle structures for crash worthiness. Types of crash / roll over, Regulatory requirements for crash testing - Instrumentation, high speed photography, Image Analysis – Crash analysis using appropriate software.

Pedestrian Safety and Ergonomics - Anthropometry - Locations of controls.Human impact tolerance- Determination of Injury thresholds, Severity Index, Study of comparative tolerance. Study of crash dummies using appropriate software. 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. Comfort and convenient systems.
Automotive Lighting and Light Signaling Devices - Automotive lamps, design, construction, material, performance - Light signaling devices .Emerging technologies: Gas Discharge lamp, LED, Adoptive Front Lighting System (AFLS), Daylight Running Lamps (DRL).

TEXT BOOKS/REFERENCES:

1. Johnson W and Mamalis A.G., "*Crashworthiness of Vehicles*", Mechanical Engineering Publications, 2002.
2. Olson L. P., "*Forensic Aspects of Driver Perception and Response*", Lawyers and Judges, 1996.
3. Daniel J Helt, "*Recent Development in Automotive Safety Technology*", SAE International Publication, 2009.

4. Robert Bosch, "*Safety Comfort and Convenience Systems*", Wiley, 2008.
5. Richard Bishop, "*Intelligent Vehicle Technology and Trends*", Artech House, 2005.

16AT706 AUTOMOTIVE INFOTRONICS 3-0-0-3

(Prerequisite –Automotive Electronics 16AT612)

Introduction to Automotive Controllers – S12XE: 16-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. Uwe Kiencke 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.

16AT707 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

16AT708 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*." CRC Press, 1993

16AT709 MEMS (MICRO-ELECTRO-MECHANICAL SYSTEMS),

SENSORS AND TECHNOLOGIES FOR AUTOMOTIVE APPLICATIONS 3- 0- 0- 3

(Prerequisite 16AT706)

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.

16AT710 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. Introduction to conceptualization, analysis and design of these vehicles. Tractor, harvester, windrowers: engine performance and design, vehicle testing, turbo chargers and intercoolers, drive trains, chassis mechanics, hydraulic systems including PTO.

Introduction to Terramechanics and Off-road vehicle Engineering.Role and measurement and modeling of Terrain Behavior.Performance of Off-Road Vehicles.Methods for Evaluating Tracked Vehicle Performance.

Design of Mechanical and Hydraulic dredges – backhoe, tracked excavator, pick and carry crane, soil compactor.Human safety in handling the Off-Highway Mobility 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.

16AT711 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

16AT712 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.