Detailed Contents of Courses for the Programme in Automotive Engineering

AU 500 Advanced Automotive Engineering

Components of the automobile. Engineering factors in all components and sub-system areas of automobile design. Vehicle characteristics and dynamic interactions. Systems modeling approach and mathematical models for ride, vibration, handling control and power trains of automobiles. Tire mechanics, including construction, rolling resistances, traction/braking properties, cornering and aligning properties and measurement methods. Vehicle mobility, motion performance of the vehicle, characterization of resistances, propulsion system and tractive efforts. Brake system design, braking performance, brake distribution. Steady state handling. Measurement methods. Suspension system design considerations. Design and performance of an automobile from a systems point of view. External factors such as markets, financing, and sales.

AU 501 IC Engine Thermodynamics

Thermodynamic cycle analysis of the gas exchange, compression, expansion and combustion processes with dissociation. Mechanism of combustion. Fuel and additive characteristics. Real cycles. Performance characteristics. Brief analysis of the fuel metering and ignition systems. Exhaust emissions and control systems. Heat transfer, friction and lubrication systems.

AU 502 Advanced Vehicle Dynamics

Tire forces and moments, tire models. Yaw and lateral motion. Two and four wheel bicycle models. Steady state handling characteristics. Sprung and unsprung mass. Yaw-Roll Model. Segels equations. Roll center. Vehicle suspension system modeling.

AU 503 Automotive Control Systems

Review of automatic control techniques. State-space control methods. Stability, stabilization and disturbance attenuation. Modelling of vehicle dynamics. Longitudinal, lateral and vertical motion. Active and semi-active suspension control. Cruise and adaptive cruise control, driveline and driveline speed control. Yaw control through active steering, yaw- roll coupling. ABS control.

AU 504 Automotive Materials & Manufacturing

Materials in the automotive industry. Selection of materials and shapes. Materials processing and design. Interaction of materials. Performance of materials in service. Examples of new materials. Role of environmental regulations and societal pressures on the selection of alternate materials. Manufacturing processes, including casting, forging, forming, machining and molding for the automotive industry. Quality control and techniques, process selection and methods. Manufacturing considerations for various lightweight automotive structural materials. Stiffness, fatigue, vibrations, dent resistance and crush resistance. Methods of producing lightweight automotive structures are discussed. Design for manufacturing, assembly, disassembly and recycling.

TE 505 Advanced Statistics

Probability Distributions & Transfoniiation of Variables: Unifonn, Binomial, Hypergeometric, PQisson, Normal, Exponentional, Chi-square, F & T distributions: Random sampling: Sampling distribution of mean; Central limit theorem

Statistical Inference & Hypothesis Testing: Confidence & significance level; Sample size determination; Point & interval estimates; Interval estimates for population mean, population standard deviation, & population proportion. Type I & type 11 errors; One tail & two tail tests; Tests concerning means & variances.

Linear & Multiple Linear Regression & Correlation: Simple linear regression; Properties of least square estimates; Confidence limits & tests of significance; Choice of a regression model; Correlation, Estimating the coefficients; adequacy of the model
Analysis of Variance: One way classification; Tests for the equality of several variances;
Single degree of freedom comparisons; Multiple range test; Comparing treatment with a control; Comparing a set of treatments in blocks; Randomized complete block design; Random effects model.
Factorial Experiments: Two-factor experiments; Interaction in two-factor experiments; Two-factor analysis of variance; Three-factor analysis; Choice of sample size.
2K Factorial Experiments: Yates technique for computing contrasts; Factorial experiments in incomplete blocks; Fractional factorial experiments; Analysis of fractional factorial experiments.

AU 520 Automotive Powertrains
Design of automotive power transmission systems. Loads on the vehicle. Evaluation of various engine and vehicle drive ratios on acceleration performance and fuel economy. Manual transmission and automatic transmission. Combustion in CI and SI engines. Selection of combustion chamber type and shape, intake and exhaust systems. Differences between engine types. Cylinder number, configuration, size and material selection. Selection ot mixture preparation, firing order. Mechanism of combustion. Fuel and additive characteristics. Fuel metering and ignition systems. Exhaust emissions and control systems. Heat transfer, friction and lubrication systems. Air pollution. Exhaust systems. Effects of emission on a quality. Sources of auto emissions.

ME 551 Introduction to Computational Fluid Dynamics
Review of Fluid Transport Equations: Continuity Equation, Momentum Equations, V(Transport Equation, Stream Function Equation, Heat and Mass Transport Equation Turbulence Transport Equation. Classification and Application of Partial Differential Equations: Elliptic, parabolic hyperbolic partial differential equations, Laplace Equation, Heat Equation, Wave Equal Burger's Equation. Methods of Discretization of Partial Differential Equations: Taylor Series Ex Polynomial Curve Fitting, Galerkin's Integral Method, Control-Volume Method. Analysis: Truncation Errors, Round-off Errors, Aliasing Errors. Stability Analysis and Convergence: Discrete Perturbation Stability Analysis, Von Nuemal Stabthty Analysis Numerical Solution Methods: Explicit and Implicit Methods, Upwi Differencing, Power Law and Hybrid Differencing. The SIMPLE scheme, The QU scheme. Grid generation, types and grid refinement: uniform, non-uniform, simple, staggere boundary-fitted grids. Implementation of Boundary Conditions: Numerical Treatment of Dirichlet.Nuei Mixed type boundary conditions. Implementation of Boundary Conditions: Numb Treatment of Dirichiet, Nuemann, and Mixed type boundary conditions. Hands on experience with CFD software.

ME 503 Computer Aided Design (CAD)
Fundamentals of CAD: Introduction, the design process, application of computers for creating the manufacturing data base, benefits of CAD, Computers, Input / Output Storing an Image.
Geometric Modeling: Geometric Modeling Techniques: Multiple-View Two Dimensional Input, Wire Frame Geometry, Surface Models, Geometric Entities: Points Lines, Surfaces, Solids, Tesselated Modeling, Cubic Curves: Hermite Curves. Bezier Curves, B-Spline Curves, Bicubic Surfaces: Hermite Surfaces, Bezier Surfaces, B-Spline Surfaces. Solid Modelers: Solid Modeling Construction Technique: Pure Primitive Instancing (PPI), Spatial Occupancy Enumeration (SOE), Cell Decomposition (CD), Sweeping (S), Constructive Solid Geometry (CSG), Boundry Representation (BREP), Euler Formula , Solid Modeler

Storage Data Bases, Feature Recognition, Feature-Based Design Using CSG Construction, Using a BREP for Part Interpretation; Data Transfer Standards. Computer Graphics: Computer Graphics and the Part Model: Interactive Graphics, Graphics in CAD, Two-Dimensional Graphics, Two-Dimensional Transfonnations, Three-Dimensional Graphics, Three-Dimensional Transformations, Composite Transformations in Three Dimensions, Projections, Realistic Image Generation.
Concurrent Engineering: Key Definitions; Driving Forces Behind Concurrent Engineering; The Meaning of Concurrent Engineering; Schemes for Concurrent Engineering: Axiomatic Design, DFM Guideline, Design Science, Design for Assembly, The Taguchi Method for Robust Design, Manufacturing Process Design Rules, Computer-Aided DFM, Group Technology. Failure Mode and Effects Analysis, Summary of Concurrent Engineering Tools.

AU 521 Vehicle Aerodynamics
Basic formulation of fluid mechanics and aerodynamics problems. Inviscid and viscous flow. Wind tunnels and their applications to external aerodynamics. Computational aerodynamics. Comparisons between experimental results and numerical results. Aerodynamic design for drag reduction. Aerodynamics of engine cooling. Aerodynamic noise.

AU 522 Mechatronics in AE
Introduction to mechatronics. Electric circuits and components. Semiconductor electronics, operational amplifiers, digital circuits. Microcontroller programming and interfacing. Data acquisition. AD/DA conversions, sensors and actuators. Discrete-time systems and the ZTransform method, sampled-data systems.

AU 523 Emissions and Exhaust Control
Automobiles and air pollution. Exhaust systems. Effects of emission on air quality. Sources of auto emission. Evaporative emissions, refuelling losses, exhaust emissions. The combustion process. Perfect combustion, typical engine combustion. Exhaust pollutants. Hydrocarbons, nitrogen oxides, carbon monoxide, carbon dioxide. Control of emissions. Catalytic converters.

ME 504 Finite Element Analysis
FEA of One-dimensional Problems: Introduction, Basic Steps in FEA; Modeling, Discretization, Connectivity of Elements, Imposition of Boundary Conditions, Solutions & Post Processing; Applications to Fleat Transfer, Fluid Mechanics, & solid Mechanics Problems. Bending of Beams: Euler-Bernoulli Beam Element, Governing Equations, Application of FE on Beam, Beam Examples, Plane Truss Element, Frame Element, Timoshenko Beam & Frame Element, Inclusion of Constraint Equations.
Finite Element Error Analysis: Approximation Errors, Various Measures of Errors, Convergence of Solutions, Accuracy of Solutions.
Numerical Integration & Computer Implementation: Isopararneteric Formulations, Numerical Integrations, Natural Coordinates, Computer Implementation (Pre-processor, Processor, Post-processor).
FEA of Two-dimensional Problems: Introduction, Single Variable Problems; Boundary Value Problems; Model Equations, Discretization, Weak Form, Finite Element Model, Assembly, Solutions & post processing; Mesh Generation; Imposition of Boundary Conditions; Applications; Parabolic Equations; Hyperbolic Equations.
Interpolating Functions, Numerical Integration & Modelling Considerations: Interpolating Techniques; Triangular, Rectangular, & Serendipity Elements; Coordinate Transformation; Integration on a Master Element; Modelling, Mesh Generation, Load Representation.
Plane Elasticity: Assumptions of Plane Elasticity; Basic Equations, Weak Formulations;

Principle of Virtual Displacement in Matrix Fonn; Finite Element Model, Matrix & Weak Form Model; Evaluation of Integrals.
Bending of Elastic Plates: Classical Plate Model; Finite Element Model; Shear Deformable Plate Model; Displacement field, Virtual Work Statement; Shear Locking & Reduced Integration; Introduction to Time Dependent Problems; Computer Illustrative Examples.

AU 525 Noise, Vibrations and Harshness
Evaluating the vibration and acoustic characteristics of automotive systems and components. Human comfort and annoyance guidelines and standards. Sound, hearing and physiological effects of noise and vibration. Modeling and experiment methods. Modal analysis and digital signal processing. Noise sources such as gears, bearings, rotating imbalance, gas flow, combustion, impact. Source-path-receiver identification. Sound transmission, air-borne and structure-borne noise. Structural-acoustic interactions. Noise and vibration passive/active control.

AU 526 Sensors and Actuators
Advanced mechatronic sensory devices: principles of operation and applications of force, pressure, torque, flow and temperature sensors; tactile sensors; optical and non-optical linear and angular motion, displacement and proximity sensing devices. Shape recognition and colour measurement using image processing techniques. Principles and types of mechatronic actuators: electric AC and DC motors, stepping motors, linear motors, solenoids; pneumatic and hydraulic actuators. Basic error analysis and basic signal processing and conditioning for interfacing purposes: digital and analogue quantities, A/D and D/A converters; noise reduction and digital filters. Interfacing of sensing devices and actuators to computer systems.

AU 527 Fluid Power Systems and Control
Introduction to fluid power systems. Features of pneumatic and hydraulic systems. Hydraulic pumps and motors. Hydrostatic transmission. Types of valves. Pneumatic circuit components. Hydraulic circuit design. Load sensing. Fluid power servo control. Applications to steering, braking and automatic transmission systems in automobiles. Hydraulic couplings. Torque converters.

AU 528 Lubrication
Industrial importance of lubrication. Journal and thrust bearings and seals. Derivation of the governing equations. Closed form and numerical solution of the Reynolds equation. Finite element and finite difference formulations. Boundary conditions and cavitation problem. Linear stability analysis of journal bearings. Film thickness and attitude angle computation of a rotor under external loading. Friction and temperature rise in bearings. Supply oil flowrate. Design of bearings.

IM 505 Automated Manufacturing Systems
Automated flow lines; Methods of work part transport; Transfer mechanism; Buffer storage; Control functions; Automation for machining operations; Design and fabrication considerations; General tenriinology and analysis; Analysis of transfer lines without storage; Partial automation; Automated flow lines with storage buffers; Computer simulation of automated flow lines. The assembly process; Assembly systems; Manual assembly lines; The line balancing problem; Methods of line balancing; Computerized line balancing methods; Flexible manual assembly lines; Types of automated assembly systems; Parts feeding devices; Analysis of multi-station assembly machines; Analysis of a single station assembly machine. Schemes for Concurrent Engineering: Axiomatic Design, DFM Guidelines, Design for Assembly, The Taguchi Method for Robust Design, Manufacturing Process Design Rules, Computer-Aided DFM, Group Technology; Failure-Mode and Effects Analysis. Robot motions, Robot drive power, Types of

robots; Robot motions: Link geometries, Frame of reference, Orientation, Changing frames of reference, Workspace Descriptions; Robot accuracy and repeatability; Economic justification of Robots; Characteristics of robot applications; Robot Cell design; Types of robot applications, Material handling applications; Processing applications; Assembly & inspection.

IM 501 Supply Chain Management
Management systems for distribution, materials handling, inventory control, transportation planning and facilities location and analysis; Logistics information systems and development of logistics strategy. Use of planning models and software packages to demonstrate concepts of strategic partnering, adequate safety stock levels, and risk pooling. Integrated decision support systems in the management of the supply chain and logistics network design issues.

IM 515 Agile and Lean Manufacturing
Introduction to Lean Manufacturing, Value Concept, Lean Objectives & Tools, Origins of Lean Systems, Group Technology, *5S,* Single Minute Exchange of Dies, Total Productive Maintenance, Kaizen, Just-In-Time Manufacturing Systems, Push & Pull Manufacturing Systems, Poka-yoke, Toyota Production System, Introduction to Agile Manufacturing, Research Projects in Agile Manufacturing, Design of Market Responsive Supply and Distributions Manufacturing Systems.

IM 503 Maintenance Management
Typical maintenance responsibilities; Types of maintenance: Breakdown Maintenance, Preventive Maintenance, Individual Versus Group Replacement, Internal Versus External Maintenance; Determination of Crew size. Queuing Theory Application in Maintenance: Input, Queue, Service Characteristics. Mathematical Approach; Monte Carlo Simulation, Computerized Maintenance Management.

ME 524 Reliability & Quality Engineering
Reliability Measures: The reliability Function; Expected Life; Failure Rate and Hazard Function; Reliability and Hazard Function for well known Distributions such as Exponentional; Normal, Log Normal, Weibull, and Gamma Distributions; Hazard Models and Product Life; Constant Hazard Function. Linearly Increasing Hazard Function, Piecewise Linear Bathtub Hazard Function, Power Function Model, Exponential Model.
Static Reliability Model: Series System. Parallel System, Series & Parallel Combinations, Complex System Analysis, Reliability Considerations in Design.
Reliability Engineering Design: Reliability Design Methodology, Strength and Stress Distributions, Safety Factors and Reliability, Reliability Bounds in Probablistic Design. Transformation of Random Variables. Sums and Differences of Normal Random Vanables, Error Analysis, Statistical Tolerancing. Interference Theory and Reliability Computations: General Expression for Reliability; Reliability Computations for *Normally, Log* Normally, Exponentionally, Gamma and *Weibully Distributed Stress and Strength; Reliability Design Examples.*
Reliability in Design and Testing : Dynamic Reliability Models, *Reliability* Estimation, Sequential Life Testing, Bayesian Reliability in Design and Testing, Reliability Optimization.
Control Charts: Properties of the distribution of sample means, sample range estimation of standard deviation, chance and assignable causes, control charts for mean & range, control charts for mean & standard deviation, control charts for proportion defective & defects per assembly. Tests of significance to compute confidence limits. Acceptance Sampling: Introduction, OC curve, consumer & producer risks, AQL & LTPD, acceptance sampling for continuous production. acceptance by variables, single, double, & sequential sampling. Quality, Reliability, & Maintainability: Definitions, management of quality control, economic aspects of quality

decisions, capability & variability analysis, various aspects of life testing, reliability, & maintainability, Introduction to ISO 9000, and ISO 14000.

EM 504 Project Management Framework and Tools
Role of projects in organization's competitive strategy: Standard methodologies for managing projects; Project life cycle; Design-implementation interface; Estimating: preliminary and. detailed; Contractual risk allocation; Scheduling: PBS; WBS; Integration of scope, time, resource and cost dimensions of a project; Evaluation of labor, material, equipment, and subcontract resources; Scheduling techniques including CPM/ PERT, GERT, critical chain; Solving real-world project schedules; Monte Carlo simulation; Cost budgeting; Cost baseline; Cash flow analysis; Earned value analysis; Cost control; Proposal presentation; Application of software for project management (MS Project, P3).

IM 513 Six Sigma Methodologies
Introduction to Six Sigma, Internal & External Customers, DMAIC (Define, Measure, Analyze, Improve, Control) Cycle, Six Sigma Goals and Metrics, Six Sigma Training, Six Sigma Teams, Green; Black and Master Black Belt, Design for Six Sigma, DMADV (Define, Measure, Analyze, Design, Verify), Case Studies.

ME 527 Human Factor Engineering
Introduction: Scope of Ergonomics, human operator as system components; physical size and shape dynamics, anthropmetry, sources and application of energy input sensitivity, central processing capacity, input characteristics, environmental effects, heat and vibration, lightning and noise. Techniques in human factor studies; the assessment of physical activity, subjective assessment technique, methods of work analysis.
Design Requirements: Interface design; space requirements and layout visual presentation of information, auditing presentation of information, machine dynamics. control design. environmental factors, jobs aids, System evaluation.

MM 539 Corrosion Engineering
Corrosion and erosion, Stoichiornetric and non-stoichiometric crystals, Effects of impurities, Solid state electrochemistry, Oxidation of metals and alloys, Electrochemistry of corrosion. Corrosion behavior diagrams, Pourbaix diagrams, Activation Polarization. Concentration Polarization, Combined Polarization. Reference electrodes. Polarization resistance measurement, Galvanostatic behavior of metals, The three electrode cell and the F/log I Plot. Mixed Potential Theory. Mechanisms of growth and breakdown of passive films. Corrosion rate determination, Application of thermodynamics to corrosion. Crevice and Pitting corrosion, intergranular corrosion. Stress corrosion cracking, Erosion corrosion, Cavitation damage, Dc-alloying. Environmental-sensitive cracking, Mechanisms of environment-sensitive cracking. Street corrosion Electrode Kinetics, Practical aspects of environment-sensitive cracking. Electroplating, methods of corrosion prevention. Cathodic and Anodic protection, Inhibitors and types of inhibitors.Perfonnance of materials in specific environments, Soil potential and resistivity measurement, Coatings and inhibitors, Pipeline and oil rig protection.

MM *538* Polymer Engineering
Review of structure and properties of polymeric materials, their deformation and failure mechanisms, and the design and fabrication of polymeric end items. The molecular and crystallographic structures of polymers related to the elastic, viscoelastic, yield and fracture properties. Polymeric solids and reinforced polymer composites. Fabrication techniques including: extrusion, injection moulding, reaction injection molding, thermoforming, and blow molding. Configuration of Polymer chains, Thermodynamics and phase equilibria in polymer

systems, Viscoelasticity and rubber elasticity, Deformation mechanisms in glassy amorphous polymers, Toughening mechanisms in polymers, Materials selection, manufacturing engineering, properties, and applications of polymers.
Rubber, classes of dry rubber compounds, vulcanization process, Compounding of rubbers, such as carbon blacks, platicizers and age resisters, characterization of rubbers, silicon rubber

MM 540 Modern Composites Materials
Review of Composite materials, basic principles, applications and properties, Particle Reinforced Composites, Large-Particle Composites, Dispersion Strengthened Composites, processing of reinforcements, Fiber-Reinforced Composites, Influence of Fiber Length, Influence of Fiber Orientation and Concentration. Metal Matrix composites, Ceramic Matrix Composites, Hybrid composites, Processing of Fiber-Reinforced Composites, Development Processing and Characterization of Structural Composites, Treatment of thenrial, electrical, optical and magnetic properties of composite materials, Relationship of structural and processing variables to the microstructure and service behaviour of composite materials, Nanocomposites.