SEMESTER III

21AE71 PROJECT WORK I

0 0 12 6

1. Identification of a real life problem in thrust areas
2. Developing a mathematical model for solving the above problem
3. Finalisation of system requirements and specification
4. Proposing different solutions for the problem based on literature survey
5. Future trends in providing alternate solutions
6. Consolidated report preparation

Total P: 180

SEMESTER IV

21AE81 PROJECT WORK II

0 0 24 12

The project work involves the following:

Preparing a project - brief proposal including

I. Problem Identification
1. A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
2. List of possible solutions including alternatives and constraints
3. Cost benefit analysis
4. Time Line of activities

II. A report highlighting the design finalization [based on functional requirements and standards (if any)]

III. A presentation including the following:
1. Implementation Phase (Hardware / Software / both)
2. Testing and Validation of the developed system
3. Learning in the Project

IV. Consolidated report preparation

Total P: 360

PROFESSIONAL ELECTIVE THEORY COURSES

DESIGN STREAM

21AE11 ENGINE COMPONENT DESIGN

3 0 0 3

REQUIREMENTS FOR ENGINE DESIGN: Arriving at the engine capacity from vehicle performance requirements – Design of Parts Working under alternating loads - Engine balancing- kinematics of crank mechanism- Forces acting on crank mechanism. (11)

DESIGN OF PISTON ASSEMBLY: Introduction-design of crown thickness- Empirical relationships- design of CI & SI engine pistons-Compression ring design for CI & SI engine pistons-piston pin design for CI & SI engines -Design of connecting rod I section. (11)

DESIGN OF CRANK SHAFT: Introduction- Design of Journals and Crankpins- Design of Crank webs- Design of In-Line Engine crankshaft - Design of V Type Engine crankshaft (11)

DESIGN OF ENGINE SYSTEMS: Design of lubrication system elements- oil pump- oil cooler- design of cooling system components- water pump- cooling fan and radiator- computation air cooling surface. (12)

Total L: 45

REFERENCES:

1. Kolchin, A.I., Demidov, V., “Design of Automotive Engines”, MIR Publishers press, 1988.
2. Hoag, Kevin. L.,“Vehicular Engine Design”, Springer, 2012.
3. Shigley, Joseph., Mischke, Charles. and Brown, Thomas. H., “Standard Handbook of machine Design”,McGraw-Hill Professional, 2004.
4. Heywood, John., “Internal Combustion Engine Fundamentals”, McGraw Hill, 2017.

21AE12 CHASSIS COMPONENT DESIGN

3 0 0 3

CLUTCH, GEAR BOX AND DRIVE LINE: Design of single and multi-plate clutches - Selection of gear ratios - Design of gear box -Design of propeller shaft and final drive. (12)

FRAME AND SUSPENSION: Force analysis and Design procedure for frame. - Design of Suspension system – leaf spring - coil spring and torsion spring. (11)

AXLES AND STEERING: Force analysis. Design procedure for front axle. Design of rear axle - selection of tires- Determination of steering torque, -Design of linkages, steering gear box. (12)

BRAKING SYSTEM: Force analysis, design of drum and disc brakes - design of actuating mechanisms – mechanical, hydraulic and pneumatic. (10)

Total L: 45

REFERENCES:

1. Heinz Heisler . Advanced Vehicle Technology, SAE International, 2002.
2. John Fenton . Handbook of Automotive Body and Systems Design, John Wiley &Sons, 1998.
3. John Fenton . Handbook of Automotive Powertrain and Chassis Design, John Wiley &Sons,, 1998.
4. Khurmi R S, Gupta J K . A Text Book of Machine Design, New Delhi: Eursia Publishing house, 2010. 8.

21AE13 AUTOMOTIVE NVH

3 0 0 3

MEASUREMENT AND BEHAVIOUR OF SOUND: Introduction- noise measurements: the sound level meter- the decibel scale, frequency and time weightings - Sound power level- sound intensity level- sound pressure level. (11)

EXTERIOR AND INTERIONR NOISE ASSESSMENT AND CONTROL: Introduction - Air intake systems and exhaust systems: performance and noise effects - Tire noise- Noise path analysis -Measuring the sound power of IC engines and other vehicle noise sources - Engine noise - Road noise – wind noise -brake noise – squeak and rattle - Control of sound through absorption within porous materials - Control of sound by minimising transmission through panels. (12)

THE MEASUREMENT AND BEHAVIOUR OF VIBRATION: Basic vibration measurements - Analysis of vibration data: quantifying vibration - Modes of vibration and resonance -Modal analysis. (11)

SOURCES OF VIBRATION AND THEIR CONTROL: Introduction - Damping of vibrations - Vibration isolation and absorption - Engine and drivetrain vibrations - Vehicle and chassis vibrations -ride quality. (11)

Total L: 45

REFERENCES:

1. Allan Bonnick . Automotive Powertrain Science and Technology, Second ,Rouledtge Publishers, 2013.
2. Anton Fuchs, Eugenius Nijman and Hans-Herwig Priebsch, 'Automotive NVH Technology', Springer International, 2015.
3. Jian Pang, , 'Noise and Vibration Control in Automotive Bodies', John Wiley , 2018.
4. Xu Wang, 'Vehicle Noise and Vibration Refinement, Woodhead Publishing, 2014.

21AE14 MECHANICS OF COMPOSITE MATERIALS 3 0 0 3

INTRODUCTION TO COMPOSITE MATERIALS: Definitions: Composite material, Fiber, Matrix. Types of fibers and Matrix, Prepegs, Fillers and other Additives- classification of composites- Advantages of Composite Materials and Structures. Applications and Use . (12)

MICROMECHANICAL ANALYSIS OF COMPOSITE: Properties of typical composite materials-Volume and Weight Fractions-Longitudinal Strength and Stiffness. Transverse Modulus. In-plane shear Modulus. Poisson's ratio- Stress-strain relationships. Evaluation of strength and moduli. Tsai–Wu and Tsai- Hill Failure Criterion. (11)

MACROMECHANICAL ANALYSIS OF LAMINATED COMPOSITES: Introduction - Basic Assumptions- CLT-different types of laminates-, Strain-Displacement Relationship, Stress-Strain Relationships, Equilibrium Equations, Laminate Stiffness, ABD Matrices-Determination of Lamina Stresses and Strains, Types of Laminate Configuration, Balanced Laminate, Anti-symmetric Laminate, Design of composite CNG and fuel cell storage tanks. (11)

BIO-COMPOSITES AND AUTOMOTIVE APPLICATIONS: Introduction- green reinforcement fibers- PLA resin- manufacturing methods – RTM- compression molding- Fabrication automotive panels –characterization methods and design of bio-composites. (11)

Total L: 45

REFERENCES:

1. Ronald F. Gibson, "Principles of Composite Materials ", McGraw-Hill Series, 2016.
2. Richard M. Christensen, "Mechanics of Composite Materials", Dover Publications, 2012.
3. Peter I Kattan and George Z Voyiadjis "Mechanics of Composite Materials with MATLAB", Springer, 2015.
4. Mohammad Jawait and Mohd Sapuan Salit,"Green Bio-composites-Design and Applications ", Springer, 2017.

21AE15 AUTOMOTIVE PRODUCT LIFE CYCLE MANAGEMENT

3 0 0 3

MOTIVATION AND INTRODUCTION: E-commerce, B to B, B to C forms of business, extended enterprise, concepts in PDM - product life cycle, business objects, work flows, versions, views, product structure, change processes, work list, information flow model in product development, engineering bill of materials and manufacturing bill of materials. (12)

COMPONENTS OF PLM SOLUTIONS: Object oriented approach in product development solutions, phase gate process in product design - disparate databases and connectivity, use of EAI technology (middleware) - cases for preparation of combined BOM and other reports. Component supplier management and sourcing. (11)

PRODUCT VISUALISATION: CAD neutral environment and visualization of products, standard software, use of visualization in several stages of lifecycle, reviews, mark up - case studies. Role of PLM in industries, Automotive sectors, ten step approach to PLM, benefits of PLM. (11)

DETAILS OF MODULE: Details of modules in a PDM/PLM software, basics on customization and implementation of automotive PDM/PLM software. (11)

Total L: 45

REFERENCES:

1. Stark John, “Product Lifecycle Management (Volume 1)”, Springer International Publishing, 2019.
2. Stark John, “Product Lifecycle Management (Volume 2)”, Springer International Publishing, 2016.
3. Wang Lihui and Andrew Y C N, “Collaborative Design and Planning for Digital Manufacturing”, Springer-Verlag London Limited, 2009.
4. Stark John, “Product Lifecycle Management (Volume 4): The Case Studies (Decision Engineering)”, Springer Publisher,2019

21AE 16 AERODYNAMICS OF ROAD VEHICLES

3 0 0 3

AERODYNAMIC DRAG OF CARS: Introduction: Fundamentals of fluid mechanics, flow phenomenon related to vehicles, external and internal flows. Cars as a bluff body, flow field around car, air flow to passenger compartment, drag force, types of drag force, analysis of aerodynamic drag, drag coefficient of cars, strategies for aerodynamic development, low drag profiles. (12)

SHAPE OPTIMIZATION OF CARS: Front end shape modifications, front and rear wind shield angle, A and C pillar, front and rear spoilers, Roof modifications, rear end shape modifications - boat tailing, hatch back, fast back and square back, dust flow patterns at the rear, effects of gap configuration, effect of fasteners. (11)

VEHICLE HANDLING: Origin of forces and moments on a vehicle, lateral stability, methods to calculate forces and moments - vehicle dynamics under side force and winds, steady and cornering effect - steering angle and slip angle, under steer and over steer gradient, suspension effects on cornering, roll moments on front and rear axles, dirt accumulation on the vehicle, wind noise, drag reduction in commercial vehicles. (12)

WIND TUNNELS FOR AUTOMOTIVE AERODYNAMICS: Introduction, principle of wind tunnel technology, limitation of simulation, stress with scale models, full scale wind tunnels, measurement techniques, equipment and transducers, road testing methods, numerical methods. (10)

Total L: 45

REFERENCES:

1. Hucho W H, “Aerodynamic of Road vehicles ", Butterworth Co. Ltd., 1997.
2. Pope A, “Wind Tunnel Testing ", John Wiley & Sons, New York, 1974.
3. Automotive Aerodynamic: Update SP-706, SAE, 1987.
4. McCallen R, Browand F and Ross J, “The Aerodynamics of Heavy Vehicles: Trucks, Buses, and Trains”, Springer, 2004.

21AE 17 COMPUTATIONAL FLUID DYNAMICS

3 0 0 3

INTRODUCTION:Application areas of CFD, Basic concepts of fluid flow - governing equations, conservation of mass, momentum and energy – Navier-stokes and energy equation for Newtonian fluid, Mathematical classification of flow - hyperbolic, parabolic, elliptic and mixed flow types. (10)

DISCRETISATION: Finite difference method - forward, backward and central difference schemes, Explicit and implicit methods: Numerical solution for heat transfer and fluid flow problems for steady state and transient conditions, Stability analysis and error estimation. Grid generation: Choice of grid, grid-oriented velocity components, cartesian velocity components, staggered and collocated arrangements. (12)

CFD TECHNIQUES: Lax - Wendroff technique - MacCormack's technique, Relaxation technique. ADI technique, Pressure correction technique, SIMPLE algorithm. Fluid flow and convection problems: Upwind scheme, Stability criteria. (11)

TURBULENCE MODELING AND CASE STUDIES: Turbulence energy equation- one-equation model, the k-ω model, the k- ε model. Modelling and analysis of heat transfer, fluid flow and automobile components using CFD packages. (12)

Total: 45

References:
1. John D Anderson, " Computational Fluid Dynamics – The Basics with Applications", McGraw Hill, , New York, 1995.
2. Muralidhar K and Sundararajan T, "Computational Fluid Flow and Heat Transfer", Narosa Publications, New Delhi, 2003.
3. Chung T J, "Computational Fluid Dynamics", Cambridge University Press, 2002
4. David C Wilcox, "Turbulence Modeling for CFD", DCW Industries, Inc., 1993.

MANUFACTURING STREAM

21AE21 ADDITIVE MANUFACTURING

3 0 0 3

INTRODUCTION AND BASIC PRINCIPLES: Additive manufacturing, AM partsused, AM process, term additive manufacturing, distinction between AM and CNC machining, development of additive manufacturing technology, classification of AM processes, metal systems and generalized additive manufacturing process chain. (12)

AM PROCESS: Photopolymerization processes, powder bed fusion processes, extrusion-based systems, material jetting, binder jetting, sheet lamination processes, directed energy deposition processes and direct write technologies. (11)

DESIGN FOR ADDITIVE MANUFACTURING: Concepts and objectives, unique capabilities, exploring design freedoms, design tools for AM and guidelines for process selection. (11)

APPLICATIONS FOR ADDITIVE MANUFACTURE: Use of AM, software support, materials, rapid tooling, rapid manufacturing development of automotive AM applications, multiple materials, business opportunities and future directions. (11)

Total L: 45

References:
1. 1.Gibson.I, Rosen.D, Stucker.B, Khorasani.M, "Additive Manufacturing Technologies", Springer, 2020.
2. Gebhardt, Hotter, "Additive Manufacturing", Hanser Publications, 2016.
3. Terry Wohlers, "Wohlers Report 2020", Wohlers Associates, Inc, 2020.
4. Pham.D.T, and S.S. Dimov.S.S,"Rapid Manufacturing", Springer, 2001.

21AE22 DESIGN FOR MANUFACTURE AND ASSEMBLY

3 1 0 4

TOLERANCE AND PROCESS CAPABILITY ANALYSIS: Rules and methodologies used to design components for manual, automatic and flexible assembly, DFA index, poka-yoke, six sigma concepts; Cumulative effect of tolerances, dimensional chain analysis -equivalent tolerances method, equivalent standard tolerance grade method, equivalent influence method; Process capability, process capability metrics, C_p, C_{pk}, cost aspects. (12+4)

GEOMETRIC TOLERANCING AND SELECTIVE ASSEMBLY: Limits and fits, surface finish, review of relationship between attainable tolerance grades and different machining processes; Geometric tolerancing for manufacture as per Indian standards and ASME Y 14.5-2018 standard; Interchangeable part manufacture; Selective assembly – Model-I: group tolerances of mating parts equal; Model-II: total and group tolerances of shaft equal; Control of axial play - introducing secondary machining operations, laminated shims, selective assembly, examples. (10+3)

TRUE POSITION THEORY AND DATUM SYSTEMS: True position theory - comparison between co-ordinate and conventional method of feature location, true position tolerancing, virtual size concept, floating and fixed fasteners, projected tolerance zone, zero true position tolerance, compound assembly; Functional inspection techniques using CMM and paper layout gauging; Degrees of freedom, grouped datum systems - different types, two and three mutually perpendicular grouped datum planes; Grouped datum system with spigot and recess, pin and hole; Grouped datum system with spigot - recess pair and tongue - slot pair - computation of translational and rotational accuracy, geometric analysis and applications; Datum features - functional and manufacturing, redimensioning to suit manufacturing. (12+4)

REDESIGN, TOLERANCE CHARTING AND DFA: Redesign of castings based on parting line considerations, minimising core requirements, redesigning cast members using weldments, design guidelines for welding. Redesign of components to facilitate machining; Tolerance charting: Operation sequence for typical shaft type of components, preparation of process drawings for different operations, tolerance worksheets and centrality analysis, examples; Design for Assembly –methods used, design for assembly index, benchmarking, examples. (11+4)

Total L: 45 + T: 15 = 60

REFERENCES:
1. James G. Bralla, "Design for Manufacturability Handbook", McGraw Hill Professional, 1999.

2. Harry Peck, "Designing for Manufacture", Pitman Publications, 1983.
3. Matousek, "Engineering Design - A Systematic Approach", Blackie and Son Ltd., London, 1972.
4. Spotts M F, "Dimensioning and Tolerance for Quantity Production", Prentice Hall Inc., 1983.
5. Boothroyd G, Dewhurst P and Knight W, “Product Design for Manufacture and Assembly”, Marcell Dekker, 2015.
6. T. E. Graedel, Braden R. Allenby, “Design for environment” Prentice Hall, 1998.

21AE23 GREEN MATERIALS 3 0 0 3

GREEN AUTOBODY STRUCTURE: Green composites for structural applications – natural, synthetic and cellulose or plant fibers. Green matrix materials. Hybrid and advanced fiber materials for green composites. Production, structure and properties of green fibers. Light weighting concepts for the autobody structure by green composites. Recycling and sustainable development of composites. **(12)**

GREEN MATERIALS FOR FUTURISTIC VEHICLE TECHNOLOGY: Green energy materials - Green Chemistry and Energetic Materials, Green Oxidizers to Replace Ammonium Perchlorate, Green Liquid Propellants to Replace Hydrazine, Electric Propulsion. Green Primary Explosives - Inorganic Compounds and Organic-Based Compounds. Binder Materials for Green Propellants**.** **(11)**

GREEN MATERIALS AND TECHNOLOGIES FOR ELECTRICAL AND ELECTRONICS: Green materials - Paper, DNA and Nucleobases, Silk, Saccharides, Aloe Vera, Natural Waxes, and Gums, Cellulose and Cellulose Derivatives, Resins, Gelatin, Proteins, Peptides, Aminoacids, Natural and Nature-Inspired Semiconductors. Biocompatible Devices and Sustainable Processes for Green Electronics: Biocompatible Organic Electronic Devices for Sensing Applications - Fundamental Aspects of OTFT Sensors, Gas Sensors, Liquid Sensing, Electrolyte-Gated OTFT Biosensors, EGOFET Biosensors and OECTs Biosensors. (11)

ENVIRONMENTALLY SUSTAINABLE MANUFACTURING TECHNOLOGIES: Environmental friendly production, machining and metal joining technologies. Vegetable based cutting fluids. Zero waste manufacturing. Clean production. Natural pigments for automotive body painting. The “Green Missile” Program – Rocket and Gun Propellants. Sustainable Manufacturing of Explosives. Military Pyrotechnics. (11)

Total L:45

REFERENCES:

1. Caroline Baillie and RandikaJayasinghe, Green Composites, Woodhead Publishing, United Kingdom, 2017.
2. Tore Brinck, Green Energetic Materials, John Wiley & Sons Ltd, United Kingdom, 2014.
3. Pawan Kumar, Rakesh and Inderdeep Singh, Processing of Green Composites, Springer Nature Singapore Pte Ltd., Singapore, 2019.
4. J. Paulo Davim, Green Manufacturing Processes and Systems, Springer-Verlag Berlin Heidelberg, 2013.

21AE24 SMART MANUFACTURING

3 0 0 3

INTRODUCTION: Background and concept, history, digital thread, models, data, connections, and services, virtual prototype, digital asset, enterprise, industry, hardware, software, and features. (12)

SMART MANUFACTURING SHOP-FLOOR: Lean design for computerized numerical control machine tools, virtual commissioning for computerized numerical control machine tools, equipment energy consumption management, cyber–physical fusion, prognostics, health management and operational insights. (11)

NEXT-GENERATION MANUFACTURING AND THE VIRTUAL: Cloud, edge computing, bigdata, digital services, virtual reality, augmented reality and mixed reality, cyber–physical system, and IIOT, industrial AI and predictive analytics.(11)

IMPLEMENTING AND ADOPTING: Factory design, framework, Implementing / adopting of smart manufacture and case studies. (11)

Total L: 45

References:

1. Fei Tao, Meng Zhang, A.Y.C. Nee, “Digital Twin Driven Smart Manufacturing”, Elsevier Academic Press, 2019.
2. Fei Tao, Ang Liu,Tianliang Hu, A.Y.C. Nee, “Digital Twin Driven Smart Design”, Elsevier Academic Press, 2020.
3. Masoud Soroush, Michael Baldea, Thomas Edgar, “Smart Manufacturing”, Elsevier, 2020.
4. Hirz, M, Dietrich. W, Gfrerrer. A, Lang. J, “Integrated Computer-Aided Design in

ELECTRIFICATION STREAM

21AE31 ENERGY STORAGE DEVICES

3 0 0 3

BATTERIES: Li-ion batteries (main focus) -Principle of operation -Battery components and design Electrode-cell and battery fabrications- Building block cells-battery modules -packs Li-polymer batteries and applications -All solid-state batteries -future developments- Li-S battery, future battery Li-Air battery, frontier battery –Supercapacitors. (12)

BATTERY MANAGEMENT SYSTEMS: Primary function-modular design-sensors for BMS-thermal management systems and control- control contactors- electrical isolation.cell available energy and power-compute battery-pack available energy and power-diagnostics must a BMS report. (11)

EQUIVALENT CIRCUIT MODEL AND SOC ESTIMATION: Equivalent circuit-types-convert a continuous-time model to a discrete-time model-hysteresis in a lithium-ion celluncertainty via mean and covariance-Predict/correct mechanism of sequential probabilistic inference-The Kalman-filter gain factor-Deriving the three Kalman-filter prediction and correction steps-nonlinear EKF/UKF- prediction and Correction steps. (11)

SOH ESTIMATION AND ENERGY&POWER CALCULATIONS: Electrode aging processes-Total-Least-squares battery-cell capacity estimation-HEV/EV aging estimation- Kalman-filter approach to total capacity estimation-Battery-pack balancing-criteria for specifying a balancing Setpoint-active &passive balancing-Estimate available power using comprehensive cell model. (11)

Total L: 45

REFERENCES:

1. Grogery L. Plett. “Battery Management Systems- Volume-1: Battery Modelling”, 1st Edition, ArtechPublishers, 2015.
2. Grogery L. Plett. “Battery Management Systems- Volume-2: Equivalent- Circuits Methods”, 1st Edition, Artech Publishers, 2015.
3. Weicker Philip, "A system Approach to Lithium-ion Battery Management" Artech House, 2014.
4. Rui Xiong and WeixiangShen,."Advanced Battery Management Technologies For Electric Vehicles" Wiley,2019.

21AE32 xEV DESIGN

3 0 0 3

INTRODUCTION: Fundamentals of xEV, EV- Vehicle Dynamics-Xev types -design, development Component. (12)

VEHICLE COMPONENT ARCHITECTURE: Functional Logic for Major Components Of xEVs- Battery management systems-Battery Pack-Vehicle Control Unit-Charger DC-DC-Inverter -Motor- Vehicle instrument cluster-HVAC systems. (12)

WIRING HARNESS DESIGN AND DEVELOPMEN: Electromagnetic interference (EMI)- Electromagnetic compatibility- LV -HV systems wiring design-Safety Regulatory- Software Development Model based design. (11)

COMPONENT VEHICLE LEVEL DEVELOPMENT TESTING: Software-in-loop (SIL and HIL)- Design V cycle validation- Case Studies-Capstone Projects. (10)

Total L: 45

REFERENCES:

1. Ebrahmi, Eshani, Longo and Yamin Gao, " Modern Electric, Hybrid Electric and Fuel Cell Vehicle " 3 rd Edition, Taylor and Francis, 2018.
2. Wei Liu, "Hybrid Electric Vehicle Systems Modeling and Control" 2nd Edition, Wiley, 2017.
3. John G. Hayes and Abas Goodazari.G,"Electric Powertrain- Energy Systems, Power Electronics and Drives" Wiley, 2018.
4. Yangsheng Xu and Tin Lun Lam ,"Hybrid Electric Vehicle Design and Control’ McGraw Hill 2014.

21AE33 SMART CHARGING SYSTEMS AND INFRASTRUCTURE

3 0 0 3

INTRODUCTION: Introduction, Impact of charging strategies, identification of EV demand, EV charging options and infrastructure, energy, economic and environmental considerations, Impact of EV charging on power grid, effect of EV charging on generation and load profile, dumb charging, multiple tariff charging, Smart charging technologies, Impact on investment. **(11)**

FREQUENCY CONTROL RESERVES & VOLTAGE SUPPORT FROM EVS: Introduction, power system ancillary services, electric vehicles to support wind power integration, electric vehicle as frequency control reserves and tertiary reserves, voltage support and electric vehicle integration, properties of frequency regulation reserves, control strategies for EVs to support frequency regulation**. (12)**

ICT SOLUTIONS TO SUPPORT EV DEPLOYMENT: Introduction, Architecture and model for smart grid & EV, ICT players in smart grid, smart metering, information & communication models, functional and logical models, technology and solution for smart grid: interoperability, communication technologies. (11)

EV CHARGING FACILITY PLANNING: Energy generation scheduling, different power sources, fluctuant electricity, centralized charging schemes, decentralized charging schemes, energy storage integration into microgrid, Design of V2G and G2V Aggregator. (11)

Total L: 45

REFERENCES:

1. Emadi A, “Advanced Electric Drive Vehicles”, First Edition Taylor & Francis Group, LLC,2015.
2. HaraldNaunheimer , Bernd Bertsche , Joachim Ryborz , Wolfgang Novak "Automotive Transmission: Fundamentals, Selection, Design and Application", 2nd Edition, Springer, 2011.
3. Crissostomi E, Shorten R, Studli S and Wirth F, “Electric and Plug-in Hybrid Vehicle Networks –Optimization and Control”, First Edition Taylor & Francis Group, LLC,2018.

4. Crouse W.H, Anglin D.L, "Automotive Transmission and Power Train construction", McGraw Hill, 1976.

21AE34 POWER ELECTRONICS

3 0 0 3

DEVICES: Power Diodes- Thyristors(SCR)- MOSFET's- IGBT's- Silicon carbide based wide band devices- overview of simulation- protection circuits. (12)

PHASE CONTROLLED CONVERTERS: Single Phase Converters- Three phase converters- performance of converters circuits with battery load. (10)

CHOPPERS: Single quadrant choppers- Multiquadrant choppers- Current and voltage control operations- Choppers for H-bridge operation of actuators, xEVs applications. (12)

INVERTERS: Classification-Single phase - Three phase operations- Pulse width modulation- harmonic reduction- Direct Torque Control (DTC)and Field Oriented Control (FOC). (11)

Total L: 45

REFERENCES:

1. Muhammad H. Rashid. "Power Electronics Devices, Circuits and Applications" 4th Edition, Pearson- Dorling Kindersley,2014.
2. Ali Emadi. "Handbook of Automotive Power Electronics", Taylor and Francis, 2017.
3. Singh M., "Power Electronics" McGraw-Hill Second Edition 2014
4. Yuriy Rozanov, Sergey Ryvkin and Evgeny Chaplygin "Power Electronics Basics" CRC Press Second Edition 2015

21AE35 ALTERNATIVE POWER TRAIN

3 0 0 3

ELECTRIC VEHICLES AND PROPULSION SYSTEMS: Layout of an electric vehicle, performance of electric vehicles – Traction motor characteristics, tractive effort, transmission requirements, vehicle performance, energy consumption, advantage and limitations. DC motor drives, induction motor drives, permanent magnet motor drives and switched reluctance motor drives. (11)

PLUG-IN HYBRID ELECTRIC VEHICLES: Introduction to PHEVs, Architectures, Equivalent Electric Range of Blended PHEVs, Fuel Economy of PHEVs, Power Management of PHEVs, Component Sizing of EREVs, Component Sizing of Blended PHEVs, Vehicle-to-Grid Technology. (11)

HYBRID ELECTRIC VEHICLES: A Brief History of HEVs- Hybrid electric drivetrains - Concepts, Architectures of HEVs design, control strategies, Interdisciplinary Nature of HEVs, State of the Art of HEVs, Challenges and Key Technology of HEVs, merits and demerits. (11)

FUEL CELL VEHICLE ARCHITECTURE: Hybrid Vehicle configurations – Parallel, Series and Parallel-Series, Fuel cell Vehicle Drives, , Modeling, Simulation, and Control of Hybrid fuel cell vehicles, Advanced heating and cooling systems for hybrid fuel cell vehicles. (12)

Total L: 45

REFERENCES:

1. Mehrdad Ehsani, YiminGao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009.
2. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2011.
3. SerefSoylu "Electric Vehicles - The Benefits and Barriers", InTech Publishers, Croatia, 2011.
4. Aulice Scibioh M. and Viswanathan B., "Fuel Cells – Principles and Applications", University Press, India, 2006.
5. Barbir F., "PEM Fuel Cells: Theory and Practice" Elsevier, Burlington, 2005.

21AE 36 FUEL CELL VEHICLES

3 0 0 3

INTRODUCTION AND THERMODYNAMICS OF FUEL CELLS: Introduction-working and types of fuel cell-Low, medium and high temperature fuel cell. Enthalpy change of a reacting system, systematic Gibbs free energy, Ideal efficiency of the energy conversion, energy balance in fuel cells.First and second law of thermodynamics for fuel cells. (10)

ELECTROCHEMISTRY OF FUEL CELLS: Nernst equation, relation of the fuel consumption versus current output, stoichiometric coefficients and utilization percentages of the fuel and oxygen, mass flow rate calculation for fuel and oxygen in single cell and fuel cell stack, total voltage and current for fuel cells in parallel and serious connection, over-potential and polarizations, generous issues -water flooding and water management. (11)

FUEL CELL COMPONENTS AND FUELING: Material for conventional and new catalysts for MEA, Gas diffusion layer - Types and significance, various flow field design and their impact on performance. Fuel cell performance characteristics - Current/voltage, voltage efficiency and power density, Ohmic resistance, Kinetic performance, mass transfer effects, fuel cell

stacks, bi-polar plate, humidifiers and cooling plates. Hydrogen generation and storage technologies - various methods and their influences. (12)

FUEL CELL VEHICLE ARCHITECTURE: Hybrid Vehicle configurations – Parallel, Series and Parallel-Series, Fuel cell Vehicle Drives, Recent developments in battery technology for automobile applications, Modeling, Simulation, and Control of Hybrid fuel cell vehicles, Advanced heating and cooling systems for hybrid fuel cell vehicles .(12)

Total 45

REFERENCES:

1. FranoBabir, "PEM Fuel Cels" Theory and Practice", Elsevier Academic Press, 2005.
2. Viswanathan B. and ScibiohAulice M, "Fuel cells: Principles and Applications", University Press, 2006.
3. M. M. Mench, "Fuel cells Engines", John Wiley and Sons, 2008.
4. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, "Modem Electric, Hybrid Electric and Fuel cell Vehicles", Fundamental, Theory and design ",CRS Press, 2004.

21A37 APPLIED AUTOMOTIVE CONTROL THEORY

3 0 0 3

OPTIMAL CONTROL AND STATE ESTIMATION:-Dynamic Systems and State Space Representations-Basic Probability-Bayes Theorem- Least Squares and Weighted Least Square Estimation-Linear Kalman Filtering-matrices for the Kalman Filter. (12)

POWERTRAIN CONTROL SYSTEMS: Engine Control Loops- Control oriented Engine -modeling- Powertrain control – A/F ratio & spark- Powertrain control – idle speed Control -Transmission Control-Powertrain control - Hybrid electric vehicles. (11)

VEHICLE CONTROL SYSTEMS: Cruise-Controller Design- Antilock Braking Systems- Traction Control -Vehicle Stability Control. (11)

VERTICAL CONTROL SYSTEMS: Optimal Active Suspension- Single-DOF Model- Two-DOF Model Active Suspension with State Estimation. (11)

Total L: 45

References:

1. Rajamani, "Vehicle Dynamics and Control", Springer- Mechanical Engineering Series, 2012.
2. Simon.D, "Optimal State Estimation- Kalman, H infinity, Non linear Approaches "John Wiley, 2006.
3. A. GalipUlsoy, Huei Peng, and Melih Çakmakci. "Automotive Control Systems", 1st Edition Cambridge Press, 2012.
4.Zongxuan Sun and Guoming G. Zhu. "Design and Control of Automotive Propulsion Systems", Taylor and Francis, 2015.

INTELLIGENT VEHICLE TECHNOLOGY

21AE41 AUTONOMOUS VEHICLES AND CONNECTED CARS

3 0 0 3

INTRODUCTION: The Requirements for Autonomy-Self-Driving Hardware and Software Architectures-Safety Assurance for Autonomous Vehicles-Vehicle Dynamic Modeling-Vehicle Longitudinal Control-Vehicle Lateral Control. (12)

STATE ESTIMATION AND LOCALIZATION FOR SELF-DRIVING CARS: Least Squares-State Estimation - Linear and Nonlinear Kalman Filters-GNSS/INS Sensing for Pose Estimation-LIDAR Sensing-An Autonomous Vehicle State Estimator. (10)

VISUAL PERCEPTION FOR SELF-DRIVING CARS: Basics of 3D Computer Vision-Visual Features - Detection, Description and Matching-Feedforward Neural Networks-2D Object Detection-Semantic Segmentation. (12)

MOTION PLANNING FOR SELF-DRIVING CARS: Mapping for Planning-Mission Planning in Driving Environments-Dynamic Object Interactions-Principles of Behavior Planning-Reactive Planning in Static Environments. (11)

Total L: 45

REFERENCES:

1. Steven Waslender and Jonathan Kelly "Self- Driving Cars" Coursera,2018.
2. Ronald K. Jurgen (edited), "Autonomous Vehicle for Safer Driving", SAE International,
3. Warrendale Pennsylvania, USA,2013.
4. Thor I. Fossen, Kristin Y. Pettersen and Henk Nijmeijer, " Sensing and Control for Autonomous Vehicles-Applications to Land, Water and Air Vehicles " Springer International Publishing AG2017.

21AE42 AUTOMOTIVE INFOTRONICS

3 0 0 3

INTRODUCTION: Driver information, driver perception, driver convenience, driver monitoring, general vehicle control, longitudinal and lateral control, collision avoidance and vehicle monitoring. (11)

TELEMATICS: Telematics-Global positioning systems, geographical information systems, navigation system, Intelligent transport system,Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications (11)

SENSOR TECHNOLOGY FOR ADVANCED DRIVER ASSISTANCE SYSTEMS: Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion, Integration of Sensor Data to On-Board Control Systems. (12)

COMFORT & SECURITY SYSTEMS: Adaptive cruise control system, active suspension system, power steering, collapsible and tiltable steering column and power windows, Adaptive lighting system. Security - Anti theft technologies – mechanical, electromechanical and electronic immobilizers, alarm system, stolen vehicle tracking system, remote keyless entry, smart card system and number plate coding. (11)

Total L: 45

REFERENCES:

1. Fossen,Thor. I., Pettersen,Kristin. Y. and Nijmeijer, Henk., "Sensing and Control for Autonomous Vehicles-Applications to Land, Water and Air Vehicles" Springer International Publishing AG 2017.
2. Ronald K. Jurgen (edited), “Autonomous Vehicle for Safer Driving”, SAE International, Warrendale Pennsylvania, USA,2013.
3. Ribbens,William. B., “Understanding Automotive Electronics”, 7th Edition Butterworth-Heinemann publications, 2012.
4. Francisco Rovira Mas, Qin Zhang, Alan C. Hansen “Mechatronics and Intelligent system for vehicles” Springer 2014.

21AE43 AUTOMOTIVE SAFETY SYSTEMS

3 0 0 3

INTRODUCTION: Active and passive safety, characteristics of vehicle structures, Optimization of vehicle structures for crash worthiness - Types of crash / roll over - Tests, Regulatory requirements for crash testing - Instrumentation, high speed photography, Image Analysis.

SAFETY CONCEPTS and PEDESTRIAN SAFETY: Driving safety, conditional safety, perceptibility safety, operating safety, passive safety: exterior safety, interior safety, deformation behavior of vehicle body, speed and acceleration characteristics of passenger compartment on impact.

SAFETY SYSTEMS: Active and passive safety, airbags, seat belt tightening system, forward collision warning systems, Radar monitoring system, Ultrasonic sensor, child lock, Anti lock braking systems, EBD, ESP, traction control system and lane departure warning system.

NEW CAR ASSESSMENT PROGRAM: Body parts shell for safety–NCAP and Global Norms, Frontal and offset frontal Crash requirements, Safety for seating and seat belt anchorages; Head impact and Injury prevention.

References:

1. Najamuz Zaman “Automotive Electronics Design Fundamental’’ first edition, Springer 2015.
2. Hüseyin Abut, John H.L. Hansen, Kazuya Takeda, Pinar Boyraz “Digital Signal Processing for In-Vehicle Systems and Safety” Springer 2011.
3. Markus Maurer, Hermann Winner “Automotive Systems Engineering” Springer 2013.
4. Ulrich Seiffert, Mark Gonter “Integrated Automotive Safety Handbook” Society of Automotive Engineers 2014.

21AE44 TRANSPORT MANAGEMENT

3 0 0 3

TYPES OF ROADS AND FLEET MANAGEMENT: Modes of transport, road transport - Types of roads, advantages, motor transport in India.Route planning - Route location, stop location, route schedules, vehicle and labor scheduling. Traffic control - Traffic signals, signal timing. (11)

COSTS,FARES AND FORMS OF OWNERSHIP: Operating costs and types of vehicles - types of fare structure, types of fare collecting methods - Requirement of buses and frequency, construction of bus station. Sole proprietorship, partnership, private limited company, public limited company, statutory company, local authority undertaking / municipal transport company, joint venture. (11)

GARAGE MANAGEMENT AND VEHICLE MAINTENANCE: Garage administration, types of garages, one spanner, two spanners, three spanners, break down truck symbol, government approved workshops – Tools- Objectives of maintenance, breakdown maintenance, preventive maintenance, tire maintenance tips and failures. Fuel saving techniques and fitness certificate. (11)

LEGAL ASPECTS: Motor vehicle act 1988, Registration, necessity of permits, insurance, test of competence to drive, mistake / offences for which a driver can be punished, adult workers - Hours of work, running time, split duty, journey time, round journey time, layover, frequency. (12)

Total L: 45

REFERENCES:

1. John Dolu, manage "Fleet management ", McGraw-Hill Co., 1984.
2. Crouse, William H, Anglin, Donald L, “Automotive Mechanics”, McGraw-Hill Companies, 2007.
3. Government Publication, "The Motor vehicle Act ", 1988.
4. Kitchin L.D, "Bus operation ", Illiffe and Sons Ltd., London, 1992.

5. Gilles, Tim, “Automotive Service – Inspection, Maintenance, and Repair”, Alar Elken Publications, 2007.

21AE45 AUTOMOTIVE ELECTRONICS

3 0 0 3

OVERVIEW OF VEHICLE ELECTRONICS: Need for Electronics in Automotive Systems - Overview of Vehicle Electronic Systems, power train subsystem - starting systems, charging systems Ignition systems, electronic fuel control, chassis subsystem - ABS, TCS, & ESP – Comfort and safety subsystems night vision, airbags, seatbelt tensioners, cruise control, Lane-departure Warning. (12)

ELECTRONIC ENGINE CONTROLS: Concept of an electronic engine control system, electronic fuel injection - throttle body fuel injection, multi point fuel injection, gasoline direct injection, common rail direct injection, electronic ignition control, engine mapping, on-board diagnostics – engine control module and power train control module. (11)

AUTOMOTIVE SENSORS AND ACTUATORS: Concept of a Sensors and Actuators, Analog and digital systems, Basic measurement systems, Analog and digital signal processing, Sensor characteristics, Sensor response, Sensor error, Redundancy of sensors in ECUs, Types of sensors- Accelerometers, Engine speed, Steering wheel angle, Vehicle speed, Throttle position, Crankshaft angular position/RPM, Manifold Absolute Pressure (MAP),Actuators, Solenoids, Various types of electric motors and piezoelectric force generators. (11)

COMMUNICATION PROTOCOLS: Introduction to control networking – Communication protocols in embedded systems – SPI, I2C, USB. Vehicle communication protocols – Introduction to CAN, LIN, FLEXRAY, MOST, KWP2000. (11)

Total L: 45

REFERENCES:

1. Bosch, Robert., “Bosch Automotive Electrics and Automotive Electronics: Systems and Components, Networking and Hybrid Drive” Springer Vieweg, Plochingen, Germany, 2014.
2. Ribbens, William. B., “Understanding Automotive Electronics- An EngineeringPerspective”, the Boulevard, Langford Lane, Kidlington, Oxford, 2014
3. Halderman, James. D., “Automotive Electricity and Electronics”, Prentice Hall, USA, 2013
4. NajamuzZaman“Automotive Electronics Design Fundamental’’ first edition, Springer 2015.