DEPARTMENT OF AERONAUTICAL AND AUTOMOBILE ENGINEERING

M.TECH IN AUTOMOBILE ENGINEERING

Program Structure (Applicable to 2023 admission onwards)

YEAR	FIRST SEMESTER						SECOND SEMESTER					
	SUB CODE	SUBJECT NAME	L	T	P	C	SUB CODE	SUBJECT NAME	L	T	P	C
I	MAT 5122	Applied Numerical Methods	3	1	0	4	AAE 5213	Advanced Automotive Drivetrain Systems	3	1	0	4
	AAE 5113	Advanced Automotive Engines and Systems	3	1	0	4	AAE 5214	Vehicle Dynamics	3	1	0	4
	AAE 5114	Autotronics and Navigation	3	1	0	4	AAE ****	Program Elective-I	3	1	0	4
	AAE 5115	Vehicle Electrification and Hybridization	3	1	0	4	AAE ****	Program Elective-II	3	1	0	4
	AAE 5116	Automotive Vibration and Acoustics	3	1	0	4	AAE ****	Program Elective-III	3	1	0	4
	HUM 5051	Research Methodology and Technical Communication*	1	0	3	-	AAE ****	Open Elective	3	0	0	3
	AAE 5141	Automobile Systems Lab	0	0	3	1	HUM 5051	Research Methodology and Technical Communication*	1	0	3	2
	AAE 5142	Vehicle Parts Modeling Lab	0	0	6	2	AAE 5241	Automotive Design and Simulation Lab	0	0	3	1
							AAE 5242	Vibration and Acoustics Lab	0	0	3	1
	Total					**23**						**27**
	THIRD AND FOURTH SEMESTER											
II	AAE 6091	PROJECT WORK & INDUSTRIAL TRAINING							**0**	**0**	**0**	**25**

*TAUGHT IN BOTH SEMESTERS AND EVALUATED AND CREDITED IN THE SECOND SEMESTER

**LAB COURSES 2 & 3 AND 4&5 MAY BE COMBINED INTO ONE BY EITHER ALLOTTING 6 Hrs/WEEK OR 3 Hrs/WEEK WITH A PROVISION FOR MINI PROJECT/ASSIGMENTS

PROGRAM ELECTIVES		OPEN ELECTIVES	
COURSE CODE	**COURSE TITLE**	**COURSE CODE**	**COURSE TITLE**
AAE 5412	Automotive Communication System	AAE 5304	Alternate Energy Sources for Vehicles
AAE 5413	Automotive Embedded Systems	AAE 5305	Automotive Pollution and Control Techniques
AAE 5414	Automotive Materials and Structures		
AAE 5415	Automotive Tribology		
AAE 5416	Battery and Fuel Cell Technology		
AAE 5403	Combustion and Emission		
AAE 5417	Computational Fluid Dynamics		
AAE 5418	Crashworthiness and Occupant Safety		
AAE 5419	Engineering Optimization and Reliability		
AAE 5420	Finite Element Methods		
AAE 5421	Thermal Management in Electric Vehicles		
ELE 5422	Traction Motors and Drive Systems		
AAE 5423	Vehicle Design and Performance		

I SEMESTER

MAT 5122: APPLIED NUMERICAL METHODS [3 1 0 4]

Mathematical modeling and engineering problem solving: simple mathematical model, conservation laws and engineering. Approximations and round of errors: Accuracy and precision, error definitions, round off errors, truncation errors and Taylor's series. Roots of equations: Bracketing methods, open methods, roots of polynomials applied to engineering problems. Linear algebraic equations: LU decomposition and matrix inversion, special matrices and Gauss Seidel applied to engineering problems. Numerical Differentiation and Integration: Newton Cotes Integration formulas, integration of equations, numerical differentiation applied to engineering problems. Ordinary Differential Equations: RK methods, Boundary value and Eigen value problems. Partial Differential Equations: Finite difference method for elliptic and parabolic equation applied to engineering problems.

References:

1. Steven. C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, (2e), Tata McGraw Hill Edition, 2016.
2. Sastry S.S., Numerical Analysis for Engineers, Tata McGraw Hill Edition, 2002.

AAE 5113: ADVANCED AUTOMOTIVE ENGINES AND SYSTEMS [3 1 0 4]

Basics of automotive engines, classification, performance of engines, advances in engine technology for contemporary and futuristic automobiles, basic systems in engines and future trends, hybrid engines, intake and exhaust systems, fuel supply systems for SI and CI engines, DI and IDI systems, Engine management systems, combustion in engines, swirl and turbulence generation in combustion chamber, lubrication and cooling systems, cooling capacity analysis, ignition systems, heat exchanger design, pressure charging and analysis, alternative engines for conventional and hybrid vehicles.

References:

1. Richard Stone, Introduction to Internal Combustion Engines, McMillan, London, 2017.
2. John B. Heyhood, Internal Combustion Engines Fundamentals, McGraw Hill., 2012.
3. Obert E. F., Internal Combustion Engine analysis and Practice, International Text Book Co, Scranton,
4. Pennsylvania,1988.
5. Wiliam H Crouse, Automotive Engines, McGraw Hill Publishers, 1994.
6. Jack Erjavec, A systems approach to Automotive Technology, Delmar, Cengage Learning, New York, 2010

AAE 5114: AUTOTRONICS AND NAVIGATION [3 1 0 4]

Digital Engine control and features, control modes for fuel control, EGR control, turbocharging, flex fuel, electronics ignition control, cruise control electronics, electronics suspension system, onboard diagnostics, automatic parallel parking system, autonomous vehicle block diagram, different ECU"s used in the engine management – block diagram of the engine management system. In vehicle networks: CAN standard, format of CAN standard. Working of airbag and role of MEMS in airbag systems – centralized door locking system – climate control of cars automotive navigation system, application of navigation system, traffic control, mobile mapping, pedestrian navigation, GPS, navigation massage generation, inertial navigation system(INS), mobile land vehicle INS, strap-down INS, automatic navigation system with multiple sensors, geographical information system (GIS), GIS data base and laser scanning, location and navigation systems based on LEDs.

References:

1. William B Ribbens, Understanding Automotive Electronics, (6e), Newnes, 2003.
2. Tom Denton, Automobile Electrical and Electronics systems, (4e), Routledge Taylor & Francis group, 2012.
3. Zhao, Y., Vehicle Location and Navigation Systems, Artech House, Inc. Boston, London,1997.
4. I. Skog, Development of a low cost GPS aided INS for vehicles, Technical Report, Dept. of Signals, Sensors and Systems, Royal Institute of Technology, Sweden, 2005.
5. Richardson, B., Green, P. and Ann Arbor, Trends in North American Intelligent Transportation Systems: A Year 2000 Appraisal (Technical Report UMTRI-2000-9), MI: The University of Michigan transportation Research Institute, 2000.
6. Gilliéron P Y, A mobile mapping system for automating road data capture in real time, Optical 3D, Vienna, Oct 2001.

7. Ribbens, "Understanding Automotive Electronics", 7th Edition, Elsevier, Indian Reprint, 2013.
8. Barry Hollembeak, “Automotive Electricity, Electronics & Computer Controls”, Delmar Publishers, 2001
9. Richard K. Dupuy “Fuel System and Emission controls”, Check Chart Publication, 2000.

AAE 5115: VEHICLE ELECTRIFICATION AND HYBRIDIZATION [3 1 0 4]

Introduction to Electric Vehicle, History of EV, Concept, Principle, Types of electric vehicles, Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV), Benefits of Electric Vehicles. Foundations & Supporting Infrastructure, power Electric Motors and Power Convertors, Fundamental of Drives and DC Machines, DC Machine Drives and Control of EV Using DC Machine. Alternative vehicle architectures, hybrid-based architecture; Series-parallel architecture, EV powertrain Sizing, HEV powertrain Sizing, Electric Machines, Simple Machines, DC Machines, 3-Phase AC machines, Power Electronic Converters, DC to DC converters, Electric Motor Drivers, DC drivers, AC drivers. Control of AC machines, Hybrid vehicle control strategy. Controller Designing Embedded systems for Electric Vehicles, Sensors used in EV vehicles.

References:

1. Fundamentals of Electric vehicles: Technology & Economics, IIT Madras Prof. Ashok Jhunjhunwala Prof. Prabhjot Kaur Prof. Kaushal Kumar Jha Prof. L Kannan
2. Electrical and Plug-in Hybrid Vehicle Network, Optimization and Control, by Emanuele Crisostomi, Robert Shorten, Sonja & Fabian Wirth, 2018 Taylor & Francis Group
3. Electric and Hybrid Vehicles: Design Fundamentals, Second Edition by Iqbal Husain, 2018 Taylor & Francis Group
4. Advanced Electric Drive Vehicles by Ali Emadi, 2018 Taylor & Francis Group
5. Electric Vehicles and Renewable Energy, By Prof. Ashok Jhunjhunwala, Prof. Kaushal Jha, Prof. L Kannan, Prof. Prabhjot Kaur, IIT Madras

AAE 5116: AUTOMOTIVE VIBRATION AND ACOUSTICS [3 1 0 4]

Vibration fundamentals, SDOF undamped and damped vibrations, forced vibrations, multi-degree freedom system and modal analysis, , Random vibration, random variable and processes, Non-linear vibrations, measuring instruments, vibration transducers, vibration excitation techniques, fundamentals of signal analysis, data acquisition and processing, frequency domain analysis, dealing with random signals, fundamentals of acoustics, acoustic transducers and measurement, acoustic exciters, automotive vibration and noise. Sound insulation materials. Introduction to semi-active isolation systems and applications.

References:

1. Sujatha C., Vibration and Acoustics, Tata McGraw Hill publication, 2010.
2. Matthew Harrison, Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles, Mathew Harrison Publication, 2004.
3. Malcolm J. Crocker, Handbook of Acoustics, John Wiley & sons Publication 1993.
4. Malcolm J. Crocker, Handbook of Noise and Vibration Control, John Wiley & sons Publication, 2007.
5. Singiresu S Rao, Mechanical Vibrations, Pearson education publication, 2004.

HUM 5051: RESEARCH METHODOLOGY & TECHNICAL COMMUNICATION [1 3 0 -]

Mechanics of Research Methodology: Basic concepts: Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation. Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem. Research hypothesis: Criterion for hypothesis construction, Nature of hypothesis, need for having a working hypothesis, Characteristics and Types of hypothesis, Procedure for hypothesis testing, Sampling methods- Introduction to various sampling methods and their applications. Data Analysis: Sources of data, Collection of data, Measurement and scaling technique, and Different techniques of Data analysis. Thesis Writing and Journal Publication: thesis writing, journal and conference papers writing, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism.

References:

1. 1. Dr Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE, 2005.

2. 2. Geoffrey R. Marczyk, David DeMatteo and David Festinger, Essentials of Research Design and Methodology, John Wiley & Sons, 2004.
3. 3. John W. Creswel, Research Design: Qualitative, Quantitative & Mixed Methods Approaches, SAGE, 2004.
4. 4. Suresh C. Sinha and Anil K. Dhiman, Research Methodology (2 Vols-Set), Vedam Books, 2006.
5. 5. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International Publisher, 2008.

AAE 5141: AUTOMOBILE SYSTEMS LAB [0 0 3 1]

Servicing of basic engine systems, determination of cylinder ovality and taperness, measurement of valve parameters and reconditioning, evaluation of torque capacity of clutch, determination of transmission gear ratios, final drive ratio, steering systems, energy consumption analysis of an EV test rig, determination of drag and lift coefficient for different bodies.

References:

1. Heinz Heisler, Advanced Vehicle Technology, Butterworth – Heinemann, New York, 2002.
2. Giri N. K, Automobile Mechanics, Seventh reprint, Khanna Publishers, Delhi, 2005.
3. Kirpal singh, Automobile Engineering, Vol 1 and 2, Standard publishers distributors, N Delhi,2020
4. J Heitner, Automotive Mechanics principles and practices, CBS publishers and distributors,2004
5. Thomas Schuetz, Hucho.W.H, Aerodynamic of Road vehicles, SAE International, 2016.

AAE 5142: VEHICLE PARTS MODELING LAB [0 0 3 1]

Basics of CATIA-3DX; two-dimensional Modeling techniques, three-dimensional modeling techniques, Modeling of automotive systems and its subsystems. Assembly of components. Introduction to surface design, basic surface commands, wireframe curve generation, and tracing of car sectional views files for modeling free style tools.

References:

1. Michael Michaud, CATIA Core Tools: computer-aided three-dimensional interactive applications, McGraw Hill Professional Publication, 2012.
2. Prof Sham Tickoo, CATIA V5R17 for Engineers & Designers, Dreamtech Press Publication, 2008.
3. Nadar G Zamani, Jhonathan M Weaver, Catia V5 tutorials mechanisms, Design & Animation release 21, SDC Publication, 2012.
4. Sean Harris, Adithya Chopra, Creo Elements Pro E - Comprehensive Guide to CAD/CAM, Createspace Independent Pub, 2014.
5. Kuang-Hua Chang, Mechanism Design with Creo Elements/Pro 5.0: (Pro/ENGINEER Wildfire 5.0), SDC Publication, 2011.

II SEMESTER

AAE 5213: ADVANCED AUTOMOTIVE DRIVETRAIN SYSTEMS [3 1 0 4]

Requirement of transmission system, Layouts of automotive powertrains, analysis of power required for propulsion and desired performance, automotive clutches, design aspects of friction clutches, Determination of gear ratios for vehicles, Different types of gearboxes, Design of drive shafts, auxiliary transmission systems, Final drives and differentials, differential lock Hydrodynamic Drives,

working characteristics of torque converters, Automatic Transmission, hydraulic control system, Electronically controlled automatic transmission systems, modern transmission systems, Continuously Variable Transmissions, Dual clutch and automated Manual transmission systems , electric drives, Principles of early and modified Ward Leonard Control system, Toyota ECT-I automatic transmission with intelligent electronic control system.

References:

1. Heinz Heisler, Advanced Vehicle Technology, (2e), Butterworth – Heinemann, New York, 2002.
2. Giri N. K, Automobile Mechanics, Seventh reprint, Khanna Publishers, Delhi, 2005.
3. Garret T. K, Newton K. Steeds W. , The Motor Vehicle, (13e), Butterworth Heinemann, India, 2004.
4. Harald Naunheimer, B Bertshae, J Rayborz, W Novak, Automotive Transmission Fundamentals, Selection, Design and Application, Second Edition, Springer, 2010.
5. Yi Zhang, Chris Mi, Automotive Power Transmission Systems, Wiley, 2018.

AAE 5214: VEHICLE DYNAMICS [3 1 0 4]

Introduction to Vehicle Dynamics, Vehicle Coordinates systems, Forces acting on vehicle for different configurations, level road, gradient, maximum acceleration, car with trailer, car on banked road, Tire construction, function, Tire terminology, axis system, Mechanism of force generation, hysteresis, rolling resistance, Longitudinal slip, cornering properties, camber thrust, slip, camber stiffness, Conicity & Plysteer, Brakes, types, construction, braking force, braking performance, ABS, Brake factor, tire-road friction, brake proportioning. Aerodynamics of a car, pressure distribution on a vehicle, Aerodynamic forces, drag force, lift force, coefficients, aerodynamic aids, Shape optimization of the vehicle, driving stability. Ride quality, car vibrations, Road roughness vibrations. Types of wind tunnel and measurement techniques. Suspension isolation, responses, active control, pitch, bounce motions, Functions of a suspension, Types of suspension, axles, independent suspension, swing axle, Quarter car model.

References:

1. Thomas D. Gillespie: Fundamentals of Vehicle Dynamics, 1st Edition, Technology & Engineering publication, 1992
2. Reza N. Jazar, Vehicle Dynamics: Theory and Application by, Springer Science Business Media, LLC, 2008
3. H. B. Pacejka: Tire and Vehicle Dynamics, 1st Edition, Butterworth-Heinemann publication, 2012
4. Georg Rill: Road Vehicle Dynamics: Fundamentals and Modeling, 1st Edition, CRC press publication, 2012
5. Wolf-Heinrich Hucho, Aerodynamics of Road Vehicle, 4th Edition, Society of Automotive Engineers, U.S. 1998.

AAE 5241: AUTOMOTIVE DESIGN AND SIMULATION LAB [0 0 3 1]

Introduction to ANSYS, Introduction to elements, One-Dimensional elements –Beam, Truss, Two-Dimensional modeling analysis, Shell Elements,2D Solid Elements, 3D Solid Element and Analysis, thermal analysis, aerodynamic analysis, a crash test of vehicles.

Introduction to ABAQUS, one-dimensional elements- Modeling and analysis, two-dimensional analysis -Modeling and analysis, Modal analysis, thermal analysis, aerodynamic analysis.

References:

1. Paleti Srinivas, Krishna Chaitanya Sambana, Rajesh Kumar Datti, “Finite element using Ansys 11.0, PHI Publications, 2010.
2. R B Choudary, “Introduction to Ansys 10.0”, IK International, 2009
3. Esam M A, “Finite element simulation using Ansys,” Taylor & Francis Publication, 2010

AAE 5242: VIBRATION AND ACOUSTICS LAB [0 0 3 1]

Free vibration in different boundary conditions, forced vibration setup, Spring-mass system experiment, modal analysis using impact hammer and simulation, balancing of disc. Measuring acoustic properties using Impedance tube, Transmissibility ratio experiment. Mini project- preparation of materials and characterizing its dynamic and acoustic properties.

References:

1. Sujatha C., Vibration and Acoustics, Tata McGraw Hill publication, 2010.
2. Matthew Harrison, Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles, Mathew Harrison Publication, 2004.
3. Malcolm J. Crocker, Handbook of Acoustics, John Wiley & sons Publication, 1993.
4. Malcolm J. Crocker, Handbook of Noise and Vibration Control, John Wiley & sons Publication, 2007.
5. Singiresu S Rao, Mechanical Vibrations, Pearson education publication, 2004.

PROGRAM ELECTIVES

AAE 5416: BATTERY AND FUEL CELL TECHNOLOGY [3 1 0 4]

Introduction to Functional Safety Following ISO 26262, Description of Automotive Battery System Architecture, Classification and Application of Safety Measures for Automotive Battery Systems, Batteries in Crash Tests and Crash Simulation, Finite Elements Model of the Battery, Modelling of Mechanical Deformation, Modelling of Material and Joint Failure, Modelling of Electrical Contact and Leakage, Experimental, Thermal Runaway Experiment, Gas Analysis, Empirical Models, Equivalent Circuit Modelling, Porous Electrodes, Intercalation, Heat Generation, Cell Ageing, Large-Scale Modelling, Thermal Behaviour, Electrical Behaviour, Hydrogen Production, Hydrogen Distribution, Hydrogen Storage, Proton Exchange Membrane Fuel Cells, Sensitivity of PEM Stacks to Operating Conditions, Durability of PEM Fuel Cells, Design of Hydrogen Fuel Cell Systems for Road Vehicles, Hydrogen Fuel Cell Systems: Preliminary Remarks, Hydrogen Feeding System, Air Feeding Systems, Thermal Management System, Integrated Fuel Cell System: Efficiency, Dynamics. Metal Air batteries, Construction, working and handling.

References:

1. Pasquale Corbo, Fortunato Migliardini, Ottorino Veneri, Hydrogen Fuel Cells for Road Vehicles, Springer London Dordrecht Heidelberg New York, ISBN 978-0-85729-135-6, 2011.
2. Michael H. Westbrook, The Electric Car Development and future of battery, hybrid and fuel-cell cars, Co-published by The Institution of Engineering and Technology, London, United Kingdom, and Society of Automotive Engineers, Warrendale, PA 15096-0001, USA, ISBN 978-0-85296-013-4, 2007.
3. Alexander Thaler, Daniel Watzenig, Automotive Battery Technology, Springer Cham Heidelberg New York Dordrecht London, ISBN 978-3-319-02522-3, 2009.
4. Mehrdad Ehsani, Yimin Gao, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Press, ISBN-I O: 1420053981, ISBN-13; 978-1420053982, 2009.
5. Amir Khajepourj M. Saber Fallahi Avesta Goodarzi, Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach, Wiley, ISBN: 978-1-118-86340-4, 2010.
6. Larminie, J. and Lowry, J., 2012. Electric vehicle technology explained. John Wiley & Sons.

AAE 5423: VEHICLE DESIGN AND PERFORMANCE [3 1 0 4]

Automotive engineering development, Innovations and inventions, Commercial vehicles, Engine and transmission system development, aerodynamic evolution, steering, suspension, brakes, and safety standards. Materials and their incorporation into vehicle design, Structure and manufacturing technology of automotive materials, Mechanical and physical properties of automotive materials, material selection. Body design, styling process, Chassis design and analysis, Suspension systems and components, The role of suspension and types. The design of engine characteristics, operating cycles and deviation from it, progressive combustion. Transmissions and driveline. Braking system, Crashworthiness, and its influence on vehicle design. Control systems in automobiles, application of sensors, engine management system, electronic transmission control. A glimpse of electric vehicle design. Future possibilities.

References:

1. Julian Happian-Smith, An Introduction to Modern Vehicle Design, Butterworth-Heinemann, New Delhi, 2002
2. Jason C. Brown, A. John Robertson Stan T. Serpento, Motor Vehicle Structures: Concepts and Fundamentals, Butterworth-Heinemann, New Delhi, 2002
3. Lorenzo Morello, Lorenzo Rosti Rossini, Giuseppe Pia, Andrea Tonoli, The Automotive Body, Springer, 2011
4. Jack Erjavec, AUTOMOTIVE TECHNOLOGY, Delmar, Cengage Learning, New York, 2010

AAE 5417: COMPUTATIONAL FLUID DYNAMICS [3 1 0 4]

Governing equation of fluid mechanics, continuity equation, momentum and energy equation, Initial and boundary conditions, Equilibrium and Marching behaviour, format of differential equation, explicit Taylor series expansion, steady state conduction heat transfer, 2D heat conduction, unsteady conduction heat transfer, implicit and Crank Nicholson method, space and time marching problems, control volume techniques, diffusion convection flow, SIMPLE algorithms, boundary conditions in CFD, introduction to turbulence.

References:

1. John D Anderson Jr., Computational Fluid Dynamics- The Basics with Applications, International Edition. McGraw Hill. New York, 1995.
2. Suhas V Patankar, Numerical Heat Transfer and Fluid Flow- Hemisphere, McGraw Hill. New York, 1980.
3. H.K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics- The Finite Volume Method, Longman Scientific & Technical England, 1995.
4. K.Muralidhar and T.Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, NewDelhi, 2003.
5. Anderson D.A, Tannehill J.C, and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, Taylor and Francis Group. New York, 1997.
6. T.J. Chung., Computational Fluid Dynamics, Cambridge University Press, South Asia Edition, 2003.

AAE 5418: CRASHWORTHINESS AND OCCUPANT SAFETY [3 1 0 4]

Introduction to automotive structure, crashworthiness, occupant safety, design of vehicle structure for crash energy management, design practice for crash, crash/crash design techniques, stiff cage structure concept, vehicle front structure design, vehicle frontal collision, finite element analytical techniques and application of structure design, explicit formulation, fundamental principle for vehicle/ occupant system analysis, barrier collision, laws of motion, energy and work, restrain performance and design, human body modeling, dynamic joint modeling, dummy modeling, modeling of real human body, injury biomechanics, head injury mechanism, thoracic injury mechanism, chest injury, abdominal injury, lower extremity injury mechanism.

References:

1. Paul Du Bois Clifford C. Chou Bahig B. Fileta Tawfik B. Khalil Albert I. King Hikmat F. Mahmood Harold J. Mertz Jac Wismans, Vehicle Crashworthiness and Occupant Protection, Automotive Applications Committee American Iron and Steel Institute Southfield, Michigan, 2004. \
2. Narayan Yoganandan, Alan M. Nahum, John W. Melvin, Accidental Injury: Biomechanics and Prevention, The Medical College of Wisconsin Inc, 2015.
3. CAE Methods for Vehicle Crashworthiness and Occupant Safety, and Safety-critical Systems, SAE special publication: Society of Automotive Engineers, 2004.
4. Jorge A.C. Ambrosio, Crashworthiness: Energy Management and Occupant Protection, Springer-Verlag Wein publication Newyork, 2001.

AAE 5421: THERMAL MANAGEMENT IN ELECTRIC VEHICLES [3 1 0 4]

Current battery technologies, Battery characteristic and cost, environmental impact and material resources, battery management system, battery state estimation, battery manufacturing and testing, PCM and its types, measurement of thermal properties of PCM, Case Study I: Heat Exchanger Design and Optimization Model for EV Batteries using PCMs, Case Study 2: Melting and Solidification of Paraffin in a Spherical Shell from forced External Convection, Manufacturing Processes, Thermodynamic Analysis, Battery Heat Transfer Analysis, Battery Temperature Distribution, Battery Temperature Uniformity, Heat Exchangers, Thermal Expansion Valve, LCA of the Electric Battery, Case Study 3: Economic and Environmental Comparison of Conventional, Hybrid, Electric and Hydrogen Fuel Cell Vehicles, Case Study 4: Experimental and Theoretical Investigation of Temperature Distributions in a Prismatic Lithium-Ion Battery

References:

1. Thermal management of electrical vehicle battery systems. Ibrahim Dinçer, Halil S. Hamut, Nader Javani, Wiley, 2017.
2. ELECTRIC AND HYBRID VEHICLES: DESIGN FUNDAMENTALS, 2ND EDITION, Husain Iqbal
3. The Future of Electric Vehicles: A Sustainable Solution, Taiwo Ayodele

AAE 5412: AUTOMOTIVE COMMUNICATION SYSTEM [3 1 0 4]

Fundamentals and terminologies of Communication, IEEE standards, Network protocols:-TCP-IP, PtoP, Guided and Unguided communication, essentials of analog communication including angle modulation, global system for mobile communication, Principles of RADAR, types of RADAR, numerical problems, working principles of satellite communication, types and frequency spectrum of satellites, Bluetooth, WIFI, Mobile Ad Hoc Network: Vehicular AdHoc Network, Local Interconnect Network, Controller Area Network, Controller Area Network-Flexible Data Rate, FlexRay, Media Oriented System Transport, inter vehicular communication, intra vehicular communication, vehicle to x communication, Sensors used in modern vehicles and their interface with compatible devices, analysis of output devises: Display unit, Internet of Things (IoT): Internet of Vehicles (IoV), case studies: ADAS, IOT applications, advance sensors (NFS).

References:

1. Pratt, Timothy, and Jeremy E. Allnutt. Satellite communications. (2e), John Wiley & Sons, 2019.
2. Levanon, Nadav, and Eli Mozeson. Radar signals. (3e), John Wiley & Sons, 2004.
3. B. P. Lathi, Zhi Ding,Modern Digital and Analog Communication Systems (4e),Oxford University Press,2009.
4. Roy Blake, Leo Chartrand Wireless Communication Technology (1e), Delmar Cengage Learning,2000.
5. Gilbert Held, Inter and Intra Vehicle Communications, Auerbach Publications, 2008.
6. Tao Zhang, Luca Delgrossi, Vehicle Safety Communications Protocols, Security, and Privacy, Information Communication technology series, 2012.
7. Mohamed Kassab, Communication Technologies for Vehicles, Springer, 2015.
8. Florian Solzbacher, Jürgen Valldorf, Wolfgang Gessner, Advanced Microsystems for Automotive Applications, Springer Berl Heidelberg, 2003.
9. Hussein T. Mouftah, Melike Erol-Kantarci, and Sameh Sorour, Connected and Autonomous Vehicles in Smart Cities.
10. Radovan Miucic, Connected Vehicles, Intelligent Transportation Systems, Springer.

AAE 5419: ENGINEERING OPTIMIZATION AND RELIABILITY [3 1 0 4]

Introduction to optimal design. Elements of optimal design problem. Formulation of optimal problem. Local and global optima. Multivariable optimization without and with constraints. Heuristic search methods: simulated annealing, genetic algorithms. Multiobjective optimization and Pareto optimality. Sensitivity, trade-off analysis.
Reliability Principles, Product and system reliability, failure analysis, maintainability, availability, Reliability prediction standards.

References:

1. Rao S. S., Engineering optimization, New Age Int., 2013.
2. Kalyanmoi Deb, Optimisation for engineering Design, (2e) Prentice Hall India, 2012.
3. Ashok Belegundu and Chandrauptala T., Optimisation concepts and applications in engineering,
4. Cambridge University Press, 2011.
5. Kalyanmoi Deb, Multi-objective optimization using evolutionary algorithms, John Wiley and
6. sons, 2010
7. Rao S. S. Reliability Engineering, Pearson 2016
8. Lewis E.E. Introduction to Reliability Engineering, (2e) Wiley

AAE 5420: FINITE ELEMENT METHODS [3 1 0 4]

Introduction: Origin of FEM, application area, advantages and disadvantages, General steps of finite Element Analysis, types of elements, differential equation involved, analytical and approximate solution. Difference between FEM and FDM (Finite Difference Method), List of different commercial software available. Review of Matrix notation and operations, numerical problems. Finite Element formulation using principle of minimum potential energy, weighted residual method, Rayleigh-Ritz methods. Numerical problems. Formulation of 1 dimensional Problem: 1D bar/spring/link equation, truss equation, beam equation, numerical problems. Formulation of 2 dimensional problems: plane stress plane, strain Constant strain triangular and Linear strain Triangular element FE equation. Numerical problems. Practical consideration FE analysis, Introduction to contact and large deformation modelling. Non – linear analysis, iso-parametric formulation, FE formulation for 3D elements.

References:

1. Logan D L, First course in the Finite Element Method, Cengage learning, 2016.
2. Sheshu P., Textbook of Finite Element Analysis, PHI Learning Private Limited, 2003.
3. Robert D Cook, David S Malkus, Micheal E Plesha, Concept and Application of Finite Element Analysis, John Wiley and Sons, 1989.
4. Singiresu S Rao, The Finite Element Method in Engineering, Elsevier Inc, 2018.
5. Saeed Moaveni,Finite Element Analysis:Theory and application with ANSYS, Prentice Hall, 1999.

AAE 5414: AUTOMOTIVE MATERIALS AND STRUCTURES [3 1 0 4]

Structure of crystalline solids, imperfections, Plastic deformation Griffith's theory of failure modes –fracture toughness - fatigue - Creep mechanisms. Selection of materials and manufacturing based on functionality, Materials for Power train components, significance of iron – iron carbide equilibrium diagram in design steels and cast irons, stainless steels. Ferrous and nonferrous alloys used in automotive applications. Lightweight materials, Advanced forming & joining processes. SMART Materials - shape memory alloys, Piezo-electric materials, Types of composites and fabrication,

Mechanical behavior of composite materials, Micro mechanical behavior of composites, types of laminate, Axis system, evaluation of stiffness and compliance matrix for laminates. Stress-strain diagrams for ductile and brittle materials, Scalized structure, Symmetric and Asymmetrical vertical loads in a car Stress analysis in integral bus body. Analysis of shock and impulse. Balance of stiffness and toughness characteristics, Design of crash crumple zones, Types of impacts.

References:

1. Avner Sidney, (1991) Introduction to physical metallurgy, Mc Graw Hill International
2. Powloski, J., (1989) Vehicle Body Engineering, Business Books Ltd.
3. Madhujit Mukhopadhyay, (2005) 'Mechanics of Composite Materials and Structures, Universities Press.
4. Raghavan V, (2004) Material science and engineering, Prantice Hall India
5. Johnson, W.and Mamalis, A.G.(1995), "Crashworthiness of Vehicles, MEP, London.
6. Matthew Huang (2002), "Vehicle Crash Mechanics", CRC Press.
7. Ever J. Barbero (2010) "Introduction To Composite Materials Design", CRC Press

AAE 5415: AUTOMOTIVE TRIBOLOGY [3 1 0 4]

Introduction to tribology, laws of friction, theories of friction, wear, lubrication, viscosity, Newtonian fluid, absolute and kinematic viscosity, effect of temperature and pressure on viscosity, viscosity index, introduction to selection and classification of bearings, hydrodynamics and hydrostatic bearing, rolling element bearing, design of sliding contact bearing, journal bearing, journal bearing design and procedure, minimum film thickness, air bearings, design of hydrostatic bearings, selection and design of rolling bearing, contact stresses in bearing, fatigue life calculation, introduction to rotor dynamics.

References:

1. Michael M. Khonsari, E. Richard Booser, Applied Tribology: Bearing Design and Lubrication, Wiley publication, 2008.
2. W. Brian Rowe, Hydrostatic, Aerostatic, and Hybrid Bearing Design, Butterworth-Heinemann publication, 2012.
3. B. C. Majumdar, Introduction to Tribology of Bearings, S. Chand & Company publication, 2008.
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5. Tadeusz Stolarsk, Tribology in Machine Design, Butterworth-Heinemann publication, 2000.

AAE 5403: COMBUSTION AND EMISSION [3 1 0 4]

Introduction to combustion, principles and applications of combustion, characterization of fuels, laws of thermodynamics, fundamental laws of transport, basic reaction kinetics, global kinetics, regulatory test procedures, analysis of pollutants, pollution diagnosis, and instrumentation, NDIR analyzers, thermal conductivity and flame ionization detectors, gas chromatograph, particulate measuring systems, EGR, catalytic converter, thermal reactors, fuel modifications.

References:

1. Colin R. Ferguson, Allan T. Kirkpatrick, Internal Combustion Engines- Applied Thermosciences, John Wiley and Sons Inc., U.K., 2015.
2. Willard W. Pulkrabek, Engineering Fundamentals of Internal Combustion Engine, Pearson Education Inc., U.S.A, 2004.
3. Ganesan, Internal Combustion Engines, Tata McGraw Hill Pvt. Ltd., India, 2012.
4. J.B. Heywood, Internal Combustion Engine, Tata McGraw Hill Pvt. Ltd., India, 2018.
5. M.L. Mathur, R.P. Sharma, Internal Combustion Engine, Dhanpat Rai Publications, India, 2016.

AAE 5413: AUTOMOTIVE EMBEDDED SYSTEMS [3 1 0 4]

Introduction to microprocessor/microcontroller, graphical user interface, Embedded Automotive Protocols, Internet Standardization, inter and intra vehicular communication, Intelligent Vehicle Technologies, Secure In-Vehicle Communication, Various types of sensor and their interface with microcontroller, aurdino and raspberryPi, Anti-theft Protection, Embedded IT Security in Automotive Application, Intelligent roadways, connected vehicles, smart cities, Vehicle Informatics, Embedded systems : Airbag System, Navigation System,Adaptive Cruise Control, Rain-Sensing System, Automatic Parking System, In-vehicle entertainment system, AUTOSAR, MICROSAR, Safe Vehicle Operation, Black box, Drive by wire, Anti-lock braking system, Telematics, Satellite radio, Night vision, Backup collision sensors. Object detection and avoidance, path planning, advanced driver assistance system.

References:

1. Tao Zhang, Luca Delgrossi, Vehicle Safety Communications Protocols, Security, and Privacy, Information Communication technology series, 2012.
2. Florian Solzbacher, Jürgen Valldorf, Wolfgang Gessner, Advanced Microsystems for Automotive Applications, Springer Berl Heidelberg, 2003.
3. Hussein T. Mouftah, Melike Erol-Kantarci, and Sameh Sorour, Connected and Autonomous Vehicles in Smart Cities.
4. Radovan Miucic, Connected Vehicles, Intelligent Transportation Systems, Springer.
5. Navet, Nicolas, and Françoise Simonot-Lion, eds. Automotive embedded systems handbook. CRC press, 2017.

ELE 5422: TRACTION MOTORS AND DRIVE SYSTEMS [3 1 0 4]

Propulsion System for EVs and HEVs – Traction Motors & Classifications, Power Electronic Converters, Motor Controllers, Storage System, Understanding Flow. Electric Machines: DC Machines, 3-Phase AC Machines, Induction Motors, Permanent Magnet Machines – PM Synchronous Motors, PM Brushless DC Motors, Switched Reluctance Motors. Power Electronic Converters: Switches – Diode, BJT, MOSFET, IGBT, DC/DC Converters – Buck, Boost, Buck-Boost, Powertrain Boost, Cell Balancing Converters – Active & Passive. Electric Motor Drives: Components, DC Drives – Chopper, Acceleration, Braking, Regeneration Modes, Operating Point Analysis, Induction Motor Drives, AC Drives – Stepped Operation, Pulse Width Modulation, Current Control Methods, Inverters, PM BLDC Drives, SRM Drives – Converters, Controls, Voltage & Current Controlled Drive. Controls: Vector Control – AC Induction & PM Machines. Self Directed Learning: Hybrid Architectures & Hybrid Vehicle Components, Drive Cycles Concept, Traction Batteries, Battery Pack Management, Chargers Fundamentals, Alternative Storage - Fuel Cells, Ultra Capacitors, Flywheels.

References:

1. 1. Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals,” 2nd Edition, CRC Press, 2010.
2. 2. Ali Emadi, “Advanced Electric Drive Vehicles (Energy, Power Electronics, and Machines),” 1st Edition, CRC Press, 2014.
3. 3. Kwang Hee Nam, “AC Motor Control and Electrical Vehicle Applications,” 2nd Edition, CRC Press, 2020.
4. 4. Wei Liu, “Introduction to Hybrid Vehicle System Modeling and Control,” John Wiley & Sons, 2013.
5. 5. M. Ehsani, Y. Ga, A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design,” 2nd Edition, CRC Press, 2009.
6. 6. Tom Denton, “Electric and Hybrid Vehicles,” 2nd Edition, Tylor & Francis – CBS, 2020.
7. 7. A. Jhunjhunwala, P. Kaur, K. K. Jha, L. Kannan, “Fundamentals of Electric vehicles: Technology & Economics,” NPTEL, IIT Madras. Self Directed Learning (SDL)

OPEN ELECTIVES

AAE 5305: AUTOMOTIVE POLLUTION AND CONTROL [3 1 0 4]

Vehicle population assessment in metropolitan cities and contribution to pollution, effects on human health and environment, global warming, types of emission, transient operational effects on pollution. Pollutant formation in SI Engines, mechanism of HC and CO formation in four stroke and two stroke SI engines, NOx formation in SI engines, effects of design and operating variables on emission formation, control of evaporative emission. Two stroke engine pollution. Pollutant formation in CI engines, smoke and particulate emissions in CI engines, effects of design and operating variables on CI engine emissions. Nox formation and control. Noise pollution from automobiles, measurement and standards. Design of engine, optimum selection of operating variables for control of emissions, EGR, Thermal reactors, secondary air injection, catalytic converters, catalysts, fuel modifications, fuel cells, Two stroke engine pollution control. NDIR, FID, Chemiluminescent analyzers, Gas Chromatograph, smoke meters, emission standards, driving cycles – USA, Japan, Euro and India. Test procedures – ECE, FTP Tests. SHED Test – chassis dynamometers, dilution tunnels.

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1. Paul Degobert – Automobiles and Pollution – SAE International ISBN-1-56091-563-3, 1991.
2. Ganesan, V- “Internal Combustion Engines”- Tata McGraw-Hill Co.- 2003.
3. SAE Transactions- “Vehicle Emission”- 1982 (3 volumes).
4. Obert.E.F.- “Internal Combustion Engines”- 1988 3. Marco Nute- “ Emissions from two stroke engines, SAE Publication – 1998.

AAE 5304: ALTERNATE ENERGY SOURCES FOR VEHICLES [3 0 0 3]

Conventional fuel for automotives, risk & challenges, need for an alternate energy source, classification. Carbon based fuels- Biofuels and non-biofuels. Non-biofuels; Natural Gas; CNG and LNG-production, storage, distribution and safety, Property, study on SI and CI engines, advantages and challenges. LPG- Production, properties, study of LPG application in SI and CI engines, safety, advantages and challenges. Biofuels; Biodiesel- Production, process equipment, properties, quality standards and engine tests. Light alcohols- Methanol, potential of methanol, production, economics, safety, properties and engine tests, advantages and challenges; Ethanol-Production, Properties, engine tests, government policies, opportunity. Dimethyl ether (DME)-production, properties, application, economic issues, green house emissions, safety, advantages and challenges. Non-carboneous source- Hydrogen, Energy carrier, production, properties, economic analysis, safety, application-Engines and fuel cell, storage, benefits and barriers. Electricity, Future fuels.

References:

1. Ramadhas, Arumugam S. Alternative fuels for transportation. Taylor & Francis, 2011.
2. Hordeski, Michael Frank. Alternative fuels: the future of hydrogen. CRC Press, 2020.
3. Richard, L. "Alternative Fuels Guidebook Properties, Storage, Dispensing and Vehicle Facility
4. Modifications." Society of Automotive Engineers (SAE) (1997): 1-721.
5. Singh, Akhilendra Pratap, et al. Alternative Fuels and Their Utilization Strategies in Internal
6. Combustion Engines. Springer Singapore, 2020.