K.E. Society's

Rajarambapu Institute of Technology, Sakharale

(An Autonomous Institute, affiliated to Shivaji University, Kolhapur)

Curriculum Structure and Evaluation Scheme

(To be implemented from Academic Year **2019-20)**

Rev:Auto*Course Structure/RIT/01/2019-20*

Department: Automobile Engineering

Class: F. Y. M.Tech. Mechanical Engineering Automobile **Semester:** I

Course Code	Course	Teaching Scheme				Evaluation Scheme					
							Theory (Marks) %			Practical (Marks) %	
		L	T	P	Credits	Scheme	Max	Min % for Passing		Max	Min % for Passing
MAE1010	Motor Vehicle Technology	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
MAE1020	Automotive Design	3	1	-	4	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
PE-I	Program Elective I	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
PE-II	Program Elective II	3	-	-	3	ISE	20	40	40	--	--
						UT1	15				
						UT2	15				
						ESE	50	40			
MAE1130	Research Methodology & IPR	1	1	-	2	ISE	25	40	40	--	--
						ESE	50	40			
MAE1140	Automotive Engineering Laboratory	-	-	2	1	ISE	--	--	--	100	50
MAE1150	Vehicle Testing and Simulation Laboratory	-	-	2	1	ISE	--	--	--	50	50
						ESE	--	--		50	50
MAE1160	CAE Laboratory	-	-	4	2	ISE	--	--	--	50	50
						ESE	--	--		50	50
	Total	**13**	**2**	**8**	**19**						

Total Contact Hours/week: 23
Total Credits: 19

ISE = In Semester Evaluation, MSE (UT1+UT2) UT-I = Unit Test-I, UT-II = Unit Test-II ESE = End Semester Exam, P=Pass, NP=Not Pass

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Curriculum Structure and Evaluation Scheme

(To be implemented from Academic Year **2019-20)**

Rev:Auto*Course Structure/RIT/01/2019-20*

Department: Automobile Engineering

Class: F. Y. M.Tech. Mechanical Engineering Automobile **Semester:**II

Course Code	Course	Teaching Scheme				Evaluation Scheme					
							Theory (Marks) %			Practical (Marks) %	
		L	T	P	Credits	Scheme	Max	Min % for Passing		Max	Min % for Passing
SHP513	Advanced Mathematical Methods in Engineering	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
MAE2010	Vehicle Dynamics	3	1	-	4	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
MAE2020	Design of Electric & Hybrid Electric Vehicles	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
PE-III	Program Elective III	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
PE-IV	Program Elective IV	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
SH551	Technical Communication	2	-	-	Audit course	ISE	--	--	--	P/NP	
MAE2130	CFD Laboratory	-	-	4	2	ISE	--	--	--	50	50
						ESE	--	--		50	50
MAE2140	Mini Project	-	-	4	2	ISE	--	--	--	50	50
	Total	**17**	**1**	**8**	**20**						

Total Contact Hours/week: 26

Total Credits: 20

ISE = In Semester Evaluation, MSE (UT1+UT2) UT-I = Unit Test-I, UT-II = Unit Test-II ESE = End Semester Exam

In Vacation Industry Internship of four weeks

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Curriculum Structure and Evaluation Scheme

(To be implemented from Academic Year **2019-20)**

Rev:Auto*Course Structure/RIT/01/2019-20*

Department: Automobile Engineering

Class: S. Y. M.Tech. Mechanical Engineering Automobile **Semester**: III

Course Code	Course	Teaching Scheme				Evaluation Scheme				
		L	T	P	Credits	Scheme	Theory (Marks) %		Practical (Marks) %	
							Max	Min % for Passing	Max	Min % for Passing
MAE3010	Industry Internship	--	--	--	Audit	ISE	--	--	P/NP	
MAE3020	MOOC Course	--	--	--	03	ISE*	--	--	100	50
MAE3030	Dissertation Phase-I	--	--	08	04	ISE	--	--	100	50
MAE3040	Dissertation Phase-II	--	--	12	06	ISE	--	--	100	50
						ESE			100	50
	Total	**--**	**--**	**20**	**13**					

Total Contact Hours/week:22

Total Credits: 13

ISE = In Semester Evaluation, ESE = End Semester Exam

*Indicates that, student needs to complete Online/Certification course approved by DPGC and produce certificate of online or certification course at the time of ISE.

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Curriculum Structure and Evaluation Scheme

(To be implemented from Academic Year **2019-20)**

Rev:Auto*Course Structure/RIT/01/2019-20*

Department: Automobile Engineering

Class: S. Y. M.Tech. Mechanical Engineering Automobile **Semester:**IV

Course Code	Course	Teaching Scheme				Evaluation Scheme				
		L	T	P	Credits	Scheme	Theory (Marks) %		Practical (Marks) %	
							Max	Min % for Passing	Max	Min % for Passing
MAE4010	Dissertation Phase-III	--	--	12	06	ISE	--	--	100	50
MAE4020	Dissertation Viva-voce	--	--	20	10	ISE	--	--	100	50
						ESE			100	50
	Total			**32**	**16**					

Total Contact Hours/week: 32

Total Credits : 16

ISE = In Semester Evaluation, ESE = End Semester Exam

Program Elective-I

Sr. No.	Course Code	Course (PE-I)
1.	MAE1030	Automotive Safety
2.	MAE1040	Automotive Product Design and Development
3.	MAE1050	Automotive Electronic Systems
4.	MAE1060	Alternative Energy Sources for Vehicles
5.	MAE1070	Vehicle Body and B-I-W Structure Design

Program Elective-II

Sr. No.	Course Code	Course (PE-II)
1.	MAE1080	Simulation of I C Engines
2.	MAE1090	Smart and Intelligent Materials
3.	MAE1100	Noise, Vibration and Control
4.	MAE1110	Combustion Engineering
5.	MAE1120	Finite Element Methods

Program Elective-III

Sr. No.	Course Code	Course (PE-III)
1.	MAE2030	Heating, Ventilation and Air Conditioning
2.	MAE2040	Special Purpose Vehicles
3.	MAE2050	Farm Equipment and Machinery
4.	MAE2060	Automotive Aerodynamics
5	MAE2070	Automotive Emissions and Control Technology

Program Elective-IV

Sr. No.	Course Code	Course (PE-IV)
1.	MAE2080	Manufacturing Systems Design
2.	MAE2090	Mechanics of Composite Structures
3.	MAE2100	Computational Fluid Dynamics
4.	MAE2110	Tribology
5	MAE2120	Mechatronics

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Curriculum Structure and Evaluation Scheme

(To be implemented from Academic Year **2019-20)**

***Rev: Auto** Course Structure/RIT/01/2019-20*

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**

Course: **Motor Vehicle Technology** Course Code: **MAE1010**

L	T	P	Credits
3	-	-	3

Course Description:

Every post graduate student should have sound fundamental knowledge of various automotive systems. This course will cover the need and various aspects of automotive transmission systems, steering, braking and suspension systems of the vehicle.

Course Outcomes:

After successful completion of the course, students will be able to

1. Outline the different vehicle layouts as per the requirement of automotive application.
2. Explain fundamentals and principles of operations of different vehicle systems.
3. Describe the constructional details and working of various transmission and chassis systems.
4. Analyse the underlying mechanics of the various chassis systems.
5. Select/configure components or subsystems for diverse vehicular application.

Prerequisite: Nil

Course Content:

Unit No.	Description	Hrs.
1.	**Vehicle layouts and clutches** Vehicle layouts, weight distribution, stability, terms used in body building construction. Clutch- Necessity, types, friction clutches namely single plate clutch, multi plate clutch, centrifugal clutch, electromagnetic clutch, hydraulic clutches, fluid coupling.	06
2.	**Conventional and semi-automatic transmission** Necessity, constructional details of sliding-mesh gear box, constant-mesh gear box, synchromesh gear box, semi-automatic transmission, overdrive, torque converter- principal, single, multi stage and polyphase torque converters, performance characteristics	06
3.	**Automatic Transmission** Relative merits and demerits compared to conventional transmission, epicyclic and hydromatic transmission, continuously variable transmission. Hydrostatic drives: principles, construction and working, advantages and disadvantages	06
4.	**Frames, Front Axle and Steering Systems** Frames – types, materials, load acting, Front axles, steering geometry, wheel alignment and balancing, steering gears, power steering	06
5.	**Automotive Brakes** Necessity, stopping distance and time, brake efficiency, weight transfer, brake shoe theory, determination of braking torque, braking systems - mechanical, hydraulic, disc, drum, types of master & wheel cylinders, ABS & EBS system.	06

6.	**Suspension & Wheels and Tyres** Basic considerations, suspension systems, telescopic shock absorbers, independent suspension, wheels and tyres,	06

References:

1. K. Newton, W. Steeds and T .K. Garret, "The Motor Vehicle", 13th Edition, Butterworth Heinemann, India, 2004.
2. M. J. Nunny, Automotive Technology, SAE Publication.
3. P. M. Heldt, "Automotive Chassis", Chilton Co., New York, 1982.
4. W. Steed, "Mechanics of Road Vehicles", Illiffe Books Ltd., London. 1992.
5. Heinz Heisler, "Advanced Vehicle Technology", second edition, Butterworth – Heinemann, New York, 2002.
6. James E Duffy, "Modern Automotive Technology", Goodheart-Willcox; Seventh Edition, 2011
7. Jack Erjavec, "Automotive Technology – A systems approach", Cengage Learning, 2009
8. Automatic vehicle transmission, John Wiley Publications 1995
9. Crouse. W.H., Anglin, D.L., "Automotive Transmission and Power Trains construction ", McGraw-Hill.
10. Heldt P.M - Torque converters- Chilton Book Co.-1992
11. G. J. Giles, "Steering Suspension and Tyres", Illiffe Books Ltd., London, 1975.
12. Kirpal Singh, "Automobile Engineering Vol. I", Standard publications, New Delhi, 2011.

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: I
Course: **Automotive Design** Course Code: **MAE1020**

L	T	P	Credits
3	1	-	4

Course Description:
Automotive Design course offered for Postgraduate program which aims at designing and configuring various systems and elements like engine components, clutches, gearbox, drive shafts, final drive, differential, axles, steering, suspension and, braking. This course intends to build the competency of design, analyze and evaluate so as to modify the existing systems, if required.

Course Outcomes:
After successful completion of the course, students will be able to
1. Choose and configure engine and chassis systems for proposed vehicle and design engine components.
2. Carry out thermal and mechanical design of engine subsystems.
3. Design clutch, gear box and drive train elements for specific vehicle.
4. Analyse and select steering geometry and design steering mechanism and components.
5. Design suspension linkages, spring and shock absorber.
6. Design brake linkages and brake system

Prerequisite: Machine Design, Automotive Systems

Course Content:

Unit No.	Description	Hrs.
1.	**Engine Design** Functional design of engine, design of various engine components	06
2.	**Design of engine auxiliary system** Design of cooling, lubrication, and fuel supply system	06
3.	**Clutch and Gearbox Design** Design requirements, characteristics of clutches, sizing, selection and design of clutches, matching of engine and gearbox, saw tooth diagram, selection of gear ratios, design of gearbox	07
4.	**Propeller shaft and axle design** Drive shafts/propeller shaft assembly design, universal joint and slip joint, final drive, viscous differential, design of front and rear axle.	07
5.	**Steering and suspension design** Geometry and steering gear, spring and damper design	05
6.	**Brake system design** Requirements, design of mechanical, hydraulic brake, internal shoe design.	06

References:
1. Newton, Steed & Garret, 'The Motor Vehicle', Butterworth Heinemann.

2. Heisler Henz, 'Advanced Vehicle Technology', SAE International.
3. Naunheimer H., 'Automotive Transmission – Fundamentals, Selection, Design and Application', Springer.
4. Heisler Henz, 'Vehicle and Engine Technology', SAE International.
5. Erjavec J, 'Automotive Technology: A Systems Approach', Cengage Learning.
6. Crouse William, Anglin Donald, 'Automotive Mechanics', McGraw-Hill.
7. Julian Happian-Smith, 'An Introduction to Modern Vehicle Design', Elsevier.
8. Crolla D., 'Automotive Engineering', Butterworth-Heinemann.

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Curriculum Structure and Evaluation Scheme

(To be implemented from Academic Year **2019-20)**

***Rev: Auto** Course Structure/RIT/01/2019-20*

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**

Course: **Research Methodology and IPR** Course Code: **MAE1130**

L	T	P	Credits
1	1	-	2

Course Description:

Research Methodology is important for any student who wishes to make meaningful contribution through engineering research. The objective of this course is to provide an opportunity for the students to learn systematic research process and its components. The course also exposes the students to presenting skills which are essential for professional life. It also presents an opportunity for the students to know nature and processes involved in development of intellectual property rights.

Course Outcomes:

After completion of this course student will be able to

1. Formulate a research problem.
2. Analyze research related information
3. Prepare and present research proposal/paper by following research ethics
4. Make effective use of computers and computing tools to search, analyze information and prepare report.
5. Describe nature and processes involved in development of intellectual property rights.

Prerequisite: NIL

Content

Unit No	Description	Hrs
1.	**Meaning of Research Problem:** Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.	06
2.	**Effective Literature Studies Approaches:** Plagiarism, Research ethics, Approaches of investigation of solutions for research problem, data collection, Data analysis with software, interpretation, Necessary instrumentations.	06
3.	**Effective Technical Writing:** How to write technical report and paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	06
4.	**Nature of Intellectual Property:** Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property, Procedure for grants of patents, Patenting under PCT.	06
5.	**Patent Rights:**	06

	Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.	
6.	**New Developments in IPR:** Administration of Patent System, New developments in IPR; IPR of Biological Systems, Computer Software etc., Traditional knowledge Case Studies, IPR and IITs.	06

References –

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students", Juta & Co Ltd.
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction", Juta Academic.
3. Ranjit Kumar, , "Research Methodology: A Step by Step Guide for beginners", 2nd Edition SAGE Publication
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov , "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", Wolters Kluwar, 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Automotive Engineering Laboratory** Course Code: **MAE1140**

L	T	P	Credits
-	-	2	1

Course Description:
This laboratory is essential for supplementing classroom learning of the courses of M. Tech. Mechanical (Automobile) program. The students coming from diverse backgrounds to the program won't have been exposed to automotive systems which they are going to design, analyze and simulate as a part of the curriculum of the program. The students shall have demonstration of various automotive chassis systems and transmission elements/systems. They shall have an opportunity to observe the constructional details and working of these systems physically so as to be able to identify, draw and compare various elements/systems.

Course Outcomes:
After completion of this course student will be able to
1. Identify and list elements of various automotive systems.
2. Draw sketches /schematics of automotive systems.
3. Describe the operating principles, functions, constructional details and working of automotive systems.
4. Compare various configurations/subtypes of automotive systems.
5. Select appropriate configuration/types for automotive systems as per requirements in automotive applications.

Prerequisite: NIL

List of experiments (Any 10)

Content

Expt. No.	Description	Hrs
1.	Compare various vehicle layouts with its applications.	02
2.	Demonstration of various type of automotive clutches.	02
3.	Demonstration of conventional (manual) gear box.	02
4.	Demonstration of automatic and /or CVT transmission.	02
5.	Demonstration of hydraulic brake and air brake systems.	02
6.	Demonstration of suspensions systems	02
7.	Demonstration of steering system layout	02
8.	Demonstration of power steering	02
9.	Demonstration of front wheel steering geometry	02
10.	Demonstration of propeller shaft assembly	02
11.	Demonstration of final drive and differential assembly	02
12.	Demonstration of wheel and tyre assembly	02

References –
1. Newton, Steed & Garret, Motor Vehicles,13th Edition, Butterworth Heinemann

2. Henz Heisler, Vehicle and Engine Technology, SAE International
3. Henz Heisler, Advanced Vehicle Technology, SAE International
4. N. K. Giri, Automotive Mechanics, Khanna Publishers
5. Reimpell, H. Stoll, J. W. Betzler, The Automotive Chassis, Butterworth Heinemann
6. Giles J. G., Steering, Suspension & Tyres, Illiffe Book Ltd. London
7. William Crouse, Donald Anglin, Automotive Mechanics, McGraw-Hill
8. Gillespie T. D., Fundamentals of Vehicle Dynamics, SAE International

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Vehicle Testing and Emission Laboratory** Course Code: **MAE1150**

L	T	P	Credits
-	-	2	1

Course Description:
This course aims to develop student to carry out different vehicle testing and emission measurement. This includes two and four wheeler performance test, modal analysis of components, noise and vibration testing. Testing experiments has measurement of principle emissions using gas analysers & smoke meters and analysis of effect of catalytic convertor on emissions.

Course Outcomes:
After completion of this course student will be able to
1. Analyse performance of two and four wheelers.
2. Determine modal parameters of automotive components.
3. Select appropriate sensor for measurement of noise and vibrations in the vehicles.
4. Analyse effect of catalytic convertor on engine emissions.
5. Use appropriate gas analyser or smoke meter to measure principle emissions.

Prerequisite: Automotive Systems, Alternative Fuels and Emissions

List of experiments (Any 10)

Content

Expt. No.	Description	Hrs
1.	Performance testing of two-wheeler using Chassis Dynamometer	02
2.	On road testing of four wheeler for acceleration and brake performance	02
3.	Modal analysis of automotive components	02
4.	Measurement of Noise level inside the vehicle	02
5.	Measurement of vibrations inside the vehicle	02
6.	Trial on engine with and without catalytic converter and study of effects of catalytic converter on engine emission performance	02
7.	Measurement of HC, CO, CO_2, O_2 using exhaust gas analyzer of petrol/diesel and LPG engines	02
8.	Measurement of emission by Infra-Red Gas Analyzer (IRGA) / portable exhaust gas analyzer	02
9.	Measurement of smoke by Bosch & Hartridge smoke meter	02
10.	Measurement of petrol engine emissions with the help of multi gas analyzer	02

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **CAE Laboratory** Course Code: **MAE1160**

L	T	P	Credits
-	-	4	2

Course Description:
The platform for innovation is built on a foundation of design optimization, performance analysis, data management, and process automation. In recent years the use of computer simulation packages as a design and development tool has grown rapidly and it becomes an integral part of the research and development department. Analysis and simulation software provides a tightly integrated suite of best in class tool for modeling, analysis, and simulation. This software also optimizes the design and also provides the simulation and visualization of the performance of the optimum solution. This course covers the training on analysis and simulation software like ANSYS, HYPERWORKS, and ABAQUS etc.

Course Outcomes:
After completion of this course student will be able to
1. Develop/ select appropriate model required for simulation.
2. Apply proper constraints and boundary conditions.
3. Select suitable solver settings of simulation software.
4. Apply different post processing techniques to interpret the results.
5. Apply optimization tools from simulation software.

Prerequisite: Engineering Mathematics, Materials of Mechanics, and Heat Transfer.

Content
In this course, training on any one of the following software will be provided to the students.
1. ANSYS
2. Hyper works
3. ABAQUS

Course Content (ANSYS, HyperWorks and Abaqus)
1. 1D meshing.
2. 2D Meshing- free Mapped Meshing
3. 3D Meshing- Structured and unstructured meshing
4. Analysis setting.
5. Static analysis,
6. Steady state thermal analysis,
7. Modal analysis,
8. Nonlinear analysis
9. Dynamic analysis.
10. Transient analysis.
11. Optimization

References –
1. Robert D Cook "Concepts and applications of finite element analysis" 4th edition John

Wiley & Sons.
2. Frank L. Stasa, "Applied finite Element Analysis for Engineers", CBS International Edition, 1985.

Program Elective-I

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Automotive Safety** Course Code: **MAE1030**

L	T	P	Credits
3	-	-	3

Course Description:
Automotive safety is the need of today's world. In each and every vehicle, advanced safety systems are required to avoid accidents taking place on the roads. This course imparts knowledge in various aspects related to vehicle safety like accident avoidance, crashworthiness, pedestrian protection, crash tests, ergonomics, biomechanics and advanced safety systems like automotive collision avoidance system.

Course Outcomes:
After completion of this course student will be able to
1. Apply the fundamental concepts of vehicle safety to modern automobiles.
2. Discuss European NCAP-Test for automobiles.
3. Select appropriate crash test to be carried out for any particular collision.
4. Evaluate the level of comfort in any vehicle by developing ergonomics report.
5. Predict appropriate dummy to be used for a specific crash test.
6. Explain advanced safety systems and driver assistance systems.

Prerequisite: Vehicle Body Engineering, Mechanics of materials.

Content

Unit No	Description	Hrs
1.	**Concept of Automotive Safety:** Classification of Automotive Safety, Accident Avoidance: Human, Vehicle and Environment; Pre-Crash, Mitigation of Injuries: During Accident and After Accident; Active Safety, Passive Safety, Crashworthiness, Crashworthiness Model Requirements, Principle of Conservation of Momentum, Elastic and Inelastic Collisions, Elastic Collisions in One Dimension, Inelastic Collisions in One Dimension.	06
2.	**Pedestrian Safety:** Pedestrian Protection, Contact Points in Vehicle-Pedestrian Collisions, Injury Frequency to Various Body Regions of Pedestrian and Vehicle Collisions, Task of the Driver, European NCAP-Test, Various Test Methods, Different Pedestrian Test Procedures, Pedestrian Protection via Front Hood Airbags.	06
3.	**Impact, Collision and Crash Testing:** Frontal Impact, Side Impact, Lateral Collision, Rear-End Collision, Human Testing: Volunteer Testing, Cadaver Testing, Dummies, Crashworthiness: Deceleration Curves, The Square Wave, Injury Tolerance, Control of Deceleration, Pole Testing, Rear Testing, Side Impact Testing, Rollover Testing and Other Vehicle Tests; Compliance Testing, Component Testing, Competitive Race Testing, Proving-Ground Testing and In-Field Testing.	06

4.	**Ergonomics and Occupant Packaging:** Ergonomics, Role of Occupant Packaging in Car Design, Occupant Package Development Process: Five Steps; Strategies for Improving Occupant Accommodation and Comfort, Vehicle Seating Configuration, Strengths and Weaknesses of Methods used to Evaluate and Improve Standards of Occupant Accommodation, Ergonomic Development of a Vehicle.	06
5.	**Biomechanics, Occupant Simulation and Protection:** Injury Tolerance Limits, External and Internal Injuries; Anthropomorphic Test Devices: Hybrid II Dummy Family, Hybrid III Dummy Family, CRABI Infant Dummies, Side Impact Dummies, Rear Impact Dummies; Crash Dummy Modelling: Modelling Methodology; Real Human Body Modelling: Anthropometry; Numeric Tools used for Modelling and Simulation, Occupant and Restraint System Simulation and Pedestrian Simulation Tests; Restraint Systems: Seat Belts, Airbags, Airbags for Frontal Impacts, Side Protection by Airbags, Additional Airbag Applications, Sensors for Restraint Systems, Child Restraints; Energy Absorbing Systems.	06
6.	**Advanced Automotive Safety Systems:** Active Bonnet System, Active Headrests, Active Suspension System, Adaptive Cruise Control, Adaptive Front Lighting System, Adaptive Noise Control, Anti-Lock Brake System, Automotive Collision Avoidance System, Blind Spot Alert System; Electronic Stability Control System, Four-Wheel Steering, Forward Collision Warning System, Intelligent Airbag Sensing System, Lane Departure Warning System, Reverse Sensing Aid, Sensotronic Brake Control, Surround View Camera System, Tyre Pressure Monitoring System and Other Driver Assistance Systems.	06

References –

1. Peters, George A. and Peters, Barbara J., "Automotive Vehicle Safety", Taylor & Francis, London, 2002.
2. Seiffert, Ulrich and Wech, Lothar, "Automotive Safety Handbook", SAE International, 2007.
3. Prasad, Priya and Belwafa, Jamel E., "Vehicle Crashworthiness and Occupant Protection", Automotive Applications Committee, American Iron and Steel Institute, Southfield, Michigan, 2004.
4. Gkikas, Nikolaos, "Automotive Ergonomics: Driver-Vehicle Interaction", CRC Press, Boca Raton, 2013.
5. Bridger, R. S., "Introduction to Ergonomics", Routledge, London, 2003.
6. Happian-Smith, Julian, "An Introduction to Modern Vehicle Design", Butterworth Heinemann, First Edition, Great Britain, 2002.
7. Denton, Tom, "Automobile Electrical & Electronic Systems", Elsevier Butterworth-Heinemann, Third Edition, Burlington, 2004.
8. Erjavec, Jack, "Automotive Technology: A Systems Approach", Delmar-Cengage Learning, Fifth Edition, USA, 2010.

Program Elective-I

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Automotive Product Design and Development** Course Code: **MAE1040**

L	T	P	Credits
3	-	-	3

Course Description:
The development of a new automotive product requires an understanding of the integration of knowledge from a number of disciplines. This course provides understanding of the various phases of the product development process and the steps involved in implementing the systems engineering process. Strict and thorough implementation of the systems engineering process is a prerequisite for achieving success in any automotive product program. Otherwise, the vehicle development program may exceed its budget or time schedule, and/or the designed product may fail to meet its customer satisfaction target. Course also covers many important tools and methods used in the vehicle development process aesthetic and ergonomic considerations, economic considerations, IPR, etc.

Course Outcomes:
After completion of this course student will be able to
1. Discuss general product design process.
2. Explain automotive product development process.
3. Illustrate different product planning tools used in automotive industries.
4. Carry out financial analysis of automotive product.
5. Paraphrase ergonomic and aesthetic design consideration of automotive product.
6. Summarize legal, social issues and IPR in automotive sector.

Prerequisite: Machine Design, Automotive System Design

Content

Unit No	Description	Hrs
1.	**Introduction to Product Design** Introduction to product design, classification/ specifications of products, product life cycle & product mix, modern product development process, innovative thinking, morphology of design (seven phases), general design situations, setting specifications, requirements and ratings, their importance in the design, study of market requirements and manufacturing aspects of industrial designs.	06
2.	**Product Development Process** Introduction, processes and phases in product development, automotive product development process, flow diagram & timing chart, steps and iterations involved in the automotive product development, systems engineering process, systems engineering "V" model, vehicle attributes and attribute requirements, relationship between vehicle attributes and vehicle systems.	06

3.	**Customer Needs, Business Needs and Government Requirements** Introduction, inputs to the automotive development process, customer needs, list of customer needs, business needs, government requirements, obtaining customer inputs, observational methods, communication methods, experimentation methods, additional methods, determining business needs—product portfolio, model changes and profitability, government requirements in safety, emissions and fuel economy, government safety requirements, EPA's GHG emissions and NHTSA's CAFE standards, implementation readiness of new technologies.	06
4.	**Product Planning Tools & Financial Analysis** Introduction, benchmarking and breakthrough, benchmarking, breakthrough, benchmarking, photo-benchmarking, breakthrough, differences between benchmarking and breakthrough, benchmarking competitors' vehicles, Pugh diagram, an example of Pugh diagram application, timing charts and gateways, quality function deployment, an example of QFD chart, cascading QFDs, advantages and disadvantages of QFD, failure modes and effects analysis, an example of FEMA, failure modes and effects and criticality analysis, other product development tools, business plan, program status chart, standards, CAD tools, prototyping and simulation, physical mock-ups, technology assessment tools, types of costs and revenues in vehicle programs, non-recurring and recurring costs, costs and revenues in product life cycle, fixed vs. variable costs, make vs. buy decisions, parts and platform sharing, quality costs, manufacturing costs, safety costs, product termination costs, total life cycle costs.	06
5.	**Ergonomics and Aesthetic Design Consideration** Aspects of ergonomic and aesthetic design of automobile, anthropometry, man-machine interaction, concepts of size and texture, color, comfort criteria, psychological & physiological considerations, and economic factors in product design.	06
6.	**Legal & Social Issues and IPR** Legal and social issues: Engineering ethics and issues of society related to design of products, Patents & IP Acts. Overview, Disclosure preparation.	06

References –

1. Vivek D. Bhise, Automotive Product Development - A Systems Engineering Implementation, Taylor & Francis Group, CRC Press, 2017.
2. Karl T Ulrich, Steven D Eppinger, Product Design & Development, Tata McGraw-Hill New Delhi, 2003.
3. David G Ullman, The Mechanical Design Process, McGraw-Hill Inc.
4. N J M Roozenberg, J Ekels, N F M Roozenberg, Product Design Fundamentals and Methods, John Willey & Sons 1995.
5. Jones J. C. "Design Methods." Seeds of Human Futures, John Willey New York.
6. Bralla J. G. "Handbook of Product Design for Manufacture, McGraw-Hill New York.

7. Baldwin E. N. & Neibel B. W., Designing for Production, Edwin Homewood Illinois.
8. K. Chitale; R.C. Gupta, Product Design and Manufacturing, Prentice - Hall India.
9. Hollins B & Pugh S, Successful Product Design, Butterworths London.
10. Dieter George E., Engineering Design McGraw Hill Pub. Company, 2000.

Program Elective-I

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Automotive Electronic Systems** Course Code: **MAE1050**

L	T	P	Credits
3	-	-	3

Course Description:
The rapidly-changing automotive industry has seen the rise of embedded systems and electronics in next-generation vehicles. With emphasis on environment-friendly vehicles, optimized automobile performance, passenger comfort and safety, electronic content in automobile is growing rapidly. This course will provide various applications of electronics used in the vehicle for better performance.

Course Outcomes:
After completion of this course student will be able to
1. Demonstrate the use of electronics in automotive system
2. Illustrate engine management system and justify the use of electronics in it
3. Describe various sensors and actuators required for automobiles
4. Illustrate the applications of advanced automotive technologies embedded with electronics
5. Explain the technologies used for alternately propelled vehicles.

Prerequisite: Automotive Electricals and Electronics

Content

Unit No	Description	Hrs
1.	**Powertrain Electronics:** Application of electronics and computers, computer controlled systems, Electronic control units (ECUs) – components and construction, electronic engine management system and its components, open and closed loop control strategies, PID control, fuzzy logic and adaptive controls, various controls according to operating modes like warm up, acceleration enrichment etc.	06
2.	**Sensors & Actuators:** Types of sensors, oxygen sensors, lambda sensor, crankshaft angular position sensor, cam position sensor, Mass air flow (MAF) rate, Manifold absolute pressure (MAP), fuel metering/vehicle speed sensors, detonation sensor, Throttle position sensors. Solenoids, stepper motors, and relays, Actuators for chassis and body systems, linear and rotary actuators, solenoid and electric motor type actuators.	06
3.	**Engine Management:** Emissions, reliability and durability, Electronic Ignition Systems (Early Generations), Computer Controlled Ignition Systems, Distributorless and Direct Ignition Systems, Electronic Petrol Injection Systems, ECU, Fuel Mixture map, TBI, MPFI, Motronic, Jetronic systems, Lambda control, EGR	06

	and catalytic converter, Engine System Self-Diagnosis (On-Board Diagnostics) and EOBD, Electronic diesel control, parameters affecting combustion, noise and emissions in CI engines. Pilot, main, advanced, post injection and retarded post injection, Electronically controlled common rail diesel fuel systems.	
4.	**Chassis Management and Safety:** Electronic management of chassis systems, Vehicle motion control, anti - lock braking system, Tyre pressure monitoring system, Collision avoidance system, Traction control system, Active suspension system Keyless entry system and Electronic power steering system, Speech Synthesis, sensor multi-flexing, navigation sensors, Advanced driver information system like TELEPATH, ITS, Automatic driving control.	06
5.	**Transmission Electronics:** History of electronic control in transmission, Sensors and actuators used in transmission systems, Clutch electronic control, Manual gearbox electronic control, Torque converter electronic control, Automatic gearbox transmission management (epicyclic, fixed gear and CVT), Light hybrid powertrain technology (starter–generator), Electronic differential and four-wheel drive control.	06
6.	**Electric Vehicles and Hybrid Vehicles:** Introduction-Electric Vehicle development- system layout- basic system Components-Electric battery-solar cells-rapid charging system-motor drive system-fuel cell Electric vehicle-hybrid vehicle-series Hybrid Vehicle - parallel Hybrid Vehicle-CNG Electric hybrid vehicle.	06

References –

1. V.A.W. Hilliers, Fundamentals of Automotive Electronics, Hatchin, London.
2. Eric Chowanietz, Automobile Electronics, SAE.
3. Tom Denton, Automobile Electrical & Electronic Systems, Allied Publishers Pvt. Ltd.
4. Tomwather J. R., Cland Hunter, Automotive Computer & Control System, Prentice Inc. NJ.
5. Robert N. Brandy, Automotive Computers & Digital Instrumentation, Prentice Hall.
6. Bechfold, Understanding Automotive Electronics, SAE 1998.

Program Elective-I

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Alternative Energy Sources for Vehicles** Course Code: **MAE1060**

L	T	P	Credits
3	-	-	3

Course Description:
The course introduces the students to various alternative energy sources for the vehicle like Bio-diesel, Bio-CNG, Ethanol, Methanol, Hydrogen etc. with its properties and performance characteristics. The course contributes in achieving program outcomes of Automobile Engineering by giving brief knowledge about various energy sources for the vehicle along with optimum performance characteristics with low emission levels to fulfill the resent emission norms.

Course Outcomes:
After completion of this course student will be able to
1. Explain the various alternative energy sources for vehicle with performance characteristics.
2. Distinguish between the alternative energy sources and fossil energy sources.
3. Compare the process and conversion of various alternative energy sources and propose the best possible energy conversion system for a particular location.
4. Suggest advance engine technology for alternative energy sources.

Prerequisite: Engineering Chemistry and Internal Combustion Engines.

Content

Unit No	Description	Hrs
1.	**Introduction to Alternative Fuels** Need for alternative fuels – Availability of different alternative fuels for SI and CI engines. Availability and properties of alternate fuels, merits and demerits of various alternate fuels, introduction to alternate energy sources.	06
2.	**Alcohols as Fuels** Alcohols as fuels. Production methods of alcohols. Properties of alcohols as fuels. Methods of using alcohols in CI and SI engines. Blending, dual fuel operation, surface ignition and oxygenated additives. Performance emission and combustion characteristics in CI and SI engines.	06
3.	**Vegetable Oils as Fuels** Various vegetable oils and their important properties. Different methods of using vegetable oils engines – Blending, preheating Transesterification and emulsification of Vegetable oils – Performance in engines – Performance, Emission and Combustion Characteristics in diesel engines.	06
4.	**Biogas, Natural Gas and LPG as Fuels** Production methods of Biogas, Natural gas and LPG. Properties studies. CO2 and H2S scrubbing in Biogas., Modification required to use in SI and CI Engines- Performance and emission characteristics of Biogas, NG and LPG in	06

	SI and CI engines.	
5.	**Hydrogen as Engine Fuel** Hydrogen as a renewable energy source, Sources of Hydrogen, Fuel for Vehicles. Hydrogen Production: Direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production. Hydrogen storage systems -Solid state hydrogen storage, Gas phase hydrogen storage, Cryogenic hydrogen storage, Liquid phase hydrogen storage, performance and safety aspects of fuel cell vehicles. Fuel reformers - Advanced fuel reformers.	06
6.	**Fuel Cell, Electric and Hybrid Vehicles** Fuel cell fundamentals, The alkaline fuel cell, Acidic fuel cells, SOFC Emerging areas in Fuel cells energy and power density batteries, Layout of Electric vehicle and Hybrid vehicles – Advantages and drawbacks of electric and hybrid vehicles.	06

References –

1. Dr. S. S. Thipse, Alternative Fuels, Jaico publications.
2. N.K.Bansal and M.K.Kleeman, Renewable Sources of Energy and Conversion Systems.
3. Ayhan Demirbas, 'Biodiesel A Realistic Fuel Alternative for Diesel Engines', Springer-Verlag London Limited 2008, ISBN-13: 9781846289941
4. Gerhard Knothe, Jon Van Gerpen, Jargon Krahl, The Biodiesel Handbook‖, AOCS Press Champaign, Illinois 2005.
5. Richard L Bechtold P.E., Alternative Fuels Guide book, Society of Automotive Engineers, 1997, ISBN 0-76-80-0052-1.
6. Transactions of SAE on Biofuels (Alcohols, vegetable oils, CNG, LPG, Hydrogen, Biogas etc.).
7. Science direct Journals (Biomass & Bio energy, Fuels, Energy, Energy conversion Management, Hydrogen Energy, etc.) on biofuels.
8. Devaradjane. Dr. G., Kumaresan. Dr. M., "Automobile Engineering", AMK Publishers, 2013.
9. Ayhan Demirbas, —Biodiesel A Realistic Fuel Alternative for Diesel Engines", Springer-Verlag London Limited 2008, ISBN-13: 9781846289941
10. Maheswar Dayal, Energy today & tomorrow, -1 & B Horishr India-1982.
11. Nagpal, Power Plant Engineering, Khanna Publishers, 1991.
12. Alcohols as motor fuels progress in technology, Series No. 19 - SAE Publication USE - 1980.

Program Elective-I

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Vehicle Body and B-I-W Structure Design** Course Code:**MAE1070**

L	T	P	Credits
3	-	-	3

Course Description:
The rapidly-changing automotive industry has emphasis on environment-friendly vehicles, optimized automobile performance, passenger comfort and safety, electronic content in automobile is growing rapidly. This course is to impart knowledge in the construction and design of vehicle, aerodynamic and ergonomics concept, paneling of passenger car body trim.

Course Outcomes:
After completion of this course student will be able to
1. Identify and draw various types of body designs according to body shape and frame structures.
2. Analyze the aerodynamic forces acting on the vehicle body with their effects and the control techniques.
3. Apply various concepts of aesthetics and ergonomic while designing a vehicle body.
4. Use the principles of simple structural surface method to strengthening the vehicle body panels.
5. Design passenger and commercial vehicle bodies for symmetrical and unsymmetrical loading.

Prerequisite: Automotive Chassis Systems, Vehicle Body Engineering

Content

Unit No	Description	Hrs
1.	**Aerodynamics of vehicles** Vehicle body styles, Aerodynamic considerations in body profiling: Drag reduction, Drag force calculation, various body optimization techniques for minimum drag, and principle of wind tunnel technology.	06
2.	**Car Body Details** Shaping and packaging, Aesthetics and industrial design, formal aesthetics and shape, interior ergonomics, dashboard instruments, advances in electronic display, Types of car bodies, visibility, driver's visibility, methods of improving visibility, Ergonomics for car design, safety design, Car body construction, Safety: safety design, safety equipments for cars.; design criteria, prototype making, initial tests, crash tests on full scale model, Dummies and Instrumentation.	06
3.	**Bus Body Details** Types: mini bus, single Decker, double-decker, two level and articulated bus. Bus body layout; floor height, engine location, entrance and exit location, seating dimensions. Constructional details: frame construction, double skin construction, types of metal sections used, Regulations, Conventional and	06

	Integral type construction. Design criteria based on passenger capacity to be transported and distance to be Covered, weights and dimensions, Design of riveted joints.	
4.	**Commercial vehicle details** Types of body; flat platform, drop side, fixed side, tipper body, tanker body, Light commercial vehicle body types. Dimensions of driver's seat relation to controls. Ergonomics of driver seat position. Specialist commercial vehicles: Refrigerated vehicle, Paramedic ambulances, van pickup. Design criteria based on goods capacity to be transported and distance to be covered. Weights and dimensions, Dimensions of driver's seat relation to controls. Drivers cab design.	06
5.	**Vehicle Structure and Vehicle Body Design** Loads on the Frames, Construction and Cross sections of the frame, Basic requirement of stiffness and strength, Vehicle structure types, Demonstration of Simple Structural Surfaces (SSS), Idealized structure- structural surface, shear panel method, Layout of the design, preliminary design, safety, symmetric and asymmetrical vertical loads in car, longitudinal loads, Different loading situations- load distribution on vehicle structure, Calculation of loading cases, stress analysis of vehicle body structure under bending and torsion.	06
6.	**Body in White (BIW) Design:** Modern materials and their use into vehicle design, Types of BIW, Standard procedures in BIW design, Exercises and techniques in BIW design, Use of CAD tools to design BIW elements: upper body, under body, roof systems.	06

References –

1. J.Powloski - "Vehicle Body Engineering" - Business Books Ltd, London -1989.
2. John Fenton – "Vehicle Body Layout and Analysis –Mechanical Engg." Publications Ltd. London– 1982.
3. Reimpell J. "The Automotive Chassis: Engineering Principles" © Reed Elsevier and Professional Publishing Ltd 2001.

Program Elective-II

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Simulation of I.C. Engines** Course Code: **MAE1080**

L	T	P	Credits
3	-	-	3

Course Description:
Performance optimization of I C engine is an essential task of a design engineer before the design actual engine. Engine designer must identify market requirements and try to analyse the effect of regulatory and technological constraints on packaging, weight, cost, performance, reliability, durability, manufacturing, life cycle, and quality in virtual mode. Designer should be able to simulate engine processes, analyse engine performance and optimize performance.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Select appropriate modeling method for engine simulation.
2. Model engine systems such as Engine mechanism, valve gear train, etc.
3. Model and simulate engine thermodynamic process in air standard, fuel and cycle mode.
4. Model and simulate C I Engine process and analyse engine performance.
5. Model and simulate S I Engine process and analyse engine performance.
6. Model and simulate Engine systems such as cooling, fuel supply, injection and lubrication.

Prerequisite: I C Engine, Heat Transfer

Course Content:

Unit No.	Description	Hrs.
1.	**Introduction** Methods of mechanical system simulation, Levels of engine modeling and simulation, Ideal model of engine process, Engine mechanism simulation, Validation of simulation results,	06
2.	**Modeling of Engine combustion process** Thermodynamic relation for engine process, Air standard cycle simulation, Cycle analysis with air as working fluid, Cycle analysis with fuel air mixture as working fluid, Availability analysis of engine process,	06
3.	**Modeling and simulation of S I Engine** Modeling of Otto cycle process and analyse engine performance. Modeling of S I engine process and analyse engine performance.	06
4.	**Modeling and simulation of C I Engine** Modeling of Otto cycle process and analyse engine performance. Modeling of S I engine process and analyse engine performance. Analysis of turbo charging on engine performance	06
5.	**Simulation of 2 stroke engines** Modeling of two stroke cycle engine process and analyse engine performance. Engine port geometry, flow process in 2 stroke engine, Scavenging process	06

	simulation	
6.	**Unit 6: Modeling of engine sub systems** Modeling of engine subsystems such as cooling systems, intake systems, Exhaust systems, Modeling of HCCI, Low heat rejection / adiabatic,	06

References:

1. J. B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Book Co., 2013
2. V. Ganeshan, Computer simulation of Spark ignition Engine Process, University Press Ltd. Hydrabad, 1996
3. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980.
4. V.Ganesan, Computer Simulation of Compressed Ignition Engine Processes, Universities Press, 2002..
5. Gordon P. Blair, The Basic Design of two-Stroke engines, SAE Publications, 1990.
6. Horlock and Winterbone, The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol. I & II, Clarendon Press, 1986.
7. J.I.Ramos, Internal Combustion Engine Modeling, Hemisphere Publishing Corporation, 1989.
8. J.N.Mattaviand C A Amann, Combustion Modeling in Reciprocating Engines, Plenum Press, 1980

Program Elective-II

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Smart and Intelligent Materials** Course Code: **MAE1090**

L	T	P	Credits
3	-	-	3

Course Description:
Smart material is defined as any material that is capable of being controlled such that its response and properties change under a stimulus. A smart structure or system is capable of reacting to stimuli or the environment in a prescribed manner. The area of smart and intelligent materials is opening up and further fundamental as well as applied research is going on. There is large scope for investigations of such materials for different engineering applications and thus it brings research as well as professional opportunities for the students. The course is being offered as program elective course for Automobile post graduate program students. The main focus of the course is on appreciating the smart materials technology and its engineering applications. As a part of this course, the students are exposed to various types of smart materials like piezoelectric and magneto restrictive materials, smart composites and ER as well as MR fluids. The course offers an opportunity for students to learn a modern and relevant technology as a part of the program.

Course Outcomes:
After completion of this course student will be able to
1. Appreciate the relevance of smart and intelligent materials for engineering applications.
2. Explain magnetostrictive and piezoelectric materials and their behavior in general.
3. Demonstrate engineering applications of shape memory alloys.
4. Elaborate smart polymers as advanced materials and their applications.
5. Apply the electro rheological and magnetorheological technology for automotive applications.

Prerequisite: Material Science and Metallurgy.

Content

Unit No	Description	Hrs
1.	**Overview of smart materials:** Introduction to Smart Materials, Principles of Piezoelectricty, Piezoceramic Materials, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological fluids, Magneto-rhelological fluids.	06
2.	**HBLS materials:** Piezoelectric Materials and Magnetostrictive materials Constitutive relationship, electromechanical coupling coefficients, piezoelectric constants, piezoceramic materials.	06
3.	**HBLS materials:**	06

	Shape Memory Alloys (SMA), Shape memory alloys (SMAs), Shape memory effect, Martensitic transformation, One way and two-way SME, training of SMAs, binary and ternary alloy systems, Functional properties of SMAs.	
4.	**Smart polymers:** Electro-active Polymers (EAP), Thermally responsive polymers, Electroactive polymers microgels, Synthesis, Properties and Applications, Protein-based smart polymers, pH-responsive and photo-responsive polymers, Self-assembly, Molecular imprinting using smart polymers, Approaches to molecular imprinting, Drug delivery using smart polymers.	06
5.	**Electro-rheological fluids:** Suspensions and electro-rheological fluids – Bingham-body model – Newtonian viscosity and non-Newtonian viscosity – Principal characteristics of electro rheological fluids – The electro-rheological phenomenon – Charge migration mechanism for the dispersed phase – Electro-rheological fluid domain – Electrorheological fluid actuators – Electro-rheological fluid design parameter – Applications of Electrorheolgoical fluids.	06
6.	**Magneto-rheological fluids:** Magneto-rheology, properties, composition, operation modes, MR devices.	06

References –

1. M.V. Gandhi, B. S. Thompson, Smart Materials and Structures, Chapman & Hall, 1992.
2. D. J. Leo, Engineering Analysis of Smart Material Systems, Wiley 2007.
3. C. A. Rogers, Smart Materials, Structures and Mathematical issues, Tech. Publishing Co., USA, 1989.
4. International Journals like Smart materials and structures, IoP, Int. J. of intelligent materials systems and structures, SAGE.

Program Elective-II

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Noise, Vibration and Control** Course Code: **MAE1100**

L	T	P	Credits
3	-	-	3

Course Description:
Noise and Vibration in Automotive systems and components is detrimental as it brings discomfort and reduces life of the systems. The study of a course on Automotive Noise, Vibration and Control is therefore relevant to post-graduate students of Automobile Engineering. An awareness about fundamentals, methods of analysis and control measures will help the students to build a solid foundation to pursue research in the field. The contents of the course include revision of single degree of freedom vibrations and analysis of multi-degree of freedom vibrations of longitudinal and torsional type. It also covers methodology for measurement and analysis of noise and vibration for automotive applications. The course contents are also focused to introduce various noise legislations, vibration standards and noise as well as vibration control techniques.

Course Outcomes:
After completion of this course student will be able to
1. Identify the properties of fiber and matrix materials used in composites.
2. Select an appropriate manufacturing process for composite parts.
3. Analyze fiber composites based on the constituent properties.
4. Design engineering structures with fiber reinforced -composites.

Prerequisite: Theory of Machines

Content

Unit No	Description	Hrs
1.	**Introduction to Automotive NVH:** Noise, Vibration and Harshness and its role in automotive design and development, fundamental terms in vibration and noise, vibration and noise sources, single degree of freedom - damped and undamped vibrations, equation of motion, vibration standards, decibel addition and subtraction.	06
2.	**Multi Degree of Freedom Vibrations:** Equation of motion, Matrix formulation, Influence coefficients, Rayleigh's method, Matrix iteration method, Dunkerley's method, Forced Vibrations of Multi degree of freedom system, Multi degree of freedom torsional vibrations, Geared system, Branched system.	06
3.	**Transducer and Measurement Techniques:** Measurement system, Vibration characteristics, frequency spectrums, Transducers, exciters, impact hammers, signal conditioners, sound pressure, power and intensity measurement, microphones, sound level meters,	06

	weighting networks.	
4.	**Modal Analysis:** Definition of Modal Parameters, Experimental, Theoretical and Numerical Modal analysis, impact hammer and exciter testing, time and frequency domain analysis, damping measurement, discrete and continuous systems, transverse vibration of beams, torsional vibrations of uniform shaft.	06
5.	**NVH Legislations:** Interior Noise in Automobiles, Interior noise sources, Structure borne noise, Airborne noise, Psycho-acoustics and effect of noise on human beings, Ambient air quality standards, Noise specifications for automotive vehicles, pass-by & stationary, Refinement techniques, Sound insulation, noise path analysis, noise standards.	06
6.	**Passive Noise Treatments:** Ducts & Mufflers -Types of mufflers, performance parameters – acoustics and backpressure, Reactive and absorptive silencers and overall design considerations. Acoustic Material Characterization -Sound transmission, absorption and damping, behavior of acoustic material w.r.t. sound absorption and transmission, Standard methods for evaluating sound absorption coefficient and transmission loss, types of sound absorbers, prediction of transmission loss and flanking transmission, damping materials and their applications.	06

References –

1. A.G. Ambekar, Noise and Vibration for Engineers.
2. V.P.Singh, Mechanical Vibrations, Dhanpat Rai and Sons.
3. N. L. Meirovitch, Elements of Vibration Analysis, Mc Graw Hill New York, 1986.
4. J.P. Den Hartog, Mechanical Vibration, 4th edition, Mc Graw Hill, New York 1985.
5. S. S. Rao, Mechanical Vibration, New Age International (P) Ltd., New Delhi.
6. Rao V. Dukkipatti and J.Srinivas, Text book of mechanical Vibrations, Prentice Hall of India, New Delhi, 2004.
7. P. Srinivasan, Mechanical Vibration Analysis, Tata McGraw Hill Pub. New Delhi, 1982.
8. Grover G. K, Mechanical Vibration, Nem Chand & Brothers, Roorkee,1989.
9. Daniel J. Inman, Engineering Vibration , Prentice Hall, NJ.
10. W. T. Thomson, Theory of Vibrations, CBS Publishers, New Delhi.
11. S. P. Singal, Noise, Pollution & Control, Narosa Publishing House, New Delhi.
12. Lewis H. Bell, Industrial Noise Control : Fundamentals and Applications, CRC Press.
13. J.S. Rao and K.Gupta, Introductory Course on Theory and Practice of Mechanical Vibrations, Wiley Eastern Ltd., 1991.

Program Elective-II

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: I
Course: **Combustion Engineering** Course Code: **MAE1110**

L	T	P	Credits
3	-	-	3

Course Description:
Combustion of fuels plays an important role to prevent a great increase in energy consumption, complication of the international situation and environmental pollutant. This course introduces thermodynamics of combustion of various fuels along with SI and CI engine combustion theories. It also includes the kinematics of combustion and flame with emission control.

Course Outcomes:
After completion of this course student will be able to,
1. Carry out analysis of combustion of fuel.
2. Analysis combustion thermodynamically.
3. Apply kinematic of combustion and flame in analyzing.
4. Explain combustion in SI, CI Engines and Emission control.

Prerequisite: I. C. Engines, Alternative Fuels and Emissions.

Content

Unit No	Description	Hrs
1.	**Combustion of Fuels** Combustion equations - Theoretical air, excess air - Air fuel ratio, Equivalence ratio - Exhaust gas composition - Air fuel ratio from exhaust gas composition and heating value of fuels.	06
2.	**Thermodynamics of Combustion** Thermo-chemistry, First law analysis of reacting systems - Adiabatic combustion temperature - Second law analysis of reacting systems - Criterion for chemical equilibrium - Equilibrium constant for gaseous mixtures - Evaluation of equilibrium composition - Chemical availability.	06
3.	**Kinetics of Combustion** Rates of reaction - Reaction order and molecularity complex reactions - Chain reactions - Arrhenius rate equation, Collection theory - Activated complex theory - Explosive and general oxidative characteristics of fuels.	06
4.	**Flames** Laminar and turbulent flames - Premixed and diffusion flames - Burning velocity and its determination – Factors affecting burning velocity - Quenching, Flammability and ignition - Flame stabilization in open burners.	06
5.	**Engine Combustion** Combustion in SI and CI engines - Stages of combustion in SI and CI engines, Normal combustion and abnormal combustion - Emissions from premixed combustion - Emission from non premixed combustion - Control of emissions.	06

6.	**Combustion Generated Pollution & Its Control** Introduction, Nitrogen oxide, Thermal fixation of atmospheric nitrogen prompts, NO, Thermal NOx & control in combustors. Fuel NOx & control, post combustion destruction of NOx, Nitrogen dioxide, carbon monoxide Oxidation-Quenching, Hydrocarbons, Sulphur oxide.	06

References –

1. Irwin Glassman, Combustion, 3rd Edition, Academic Press, New York, 1996.
2. Sharma, S. P. and Chandramohan, Fuels and Combustion, Tata McGraw Hill Book Co., New Delhi, 1984.
3. Samir Sarkar, Fuels and Combustion, 2nd Edition, Orient Longman, Bombay, 1990.
4. Kuo, K. K., Principles of Combustion, John Wiley & Sons, New York, 1984.
5. Heywood, J. B., Internal Combustion Engine Fundamentals, 2nd Edition, McGraw Hill Book Co., New York, 1988.

Program Elective-II

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Finite Element Methods** Course Code: **MAE1120**

L	T	P	Credits
3	-	-	3

Course Description:
Basically, finite element methods are a mathematical tool to solve real life problems. This course is base for the numerical analysis of problems from different disciplines. Comparison with other analysis methods, meshing and formulation of finite element equation, structural, thermal and dynamic analysis, higher order elements is the major contents of the syllabus. Also it covers axisymmetric analysis.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Formulate finite element equation using weighted residual approach.
2. Formulate finite element equation using variational approach.
3. Analyze vector and scaler field problems using FEM.
4. Use isoparametric formulation for irregular geometries.
5. Formulate axisymmetric thermal and structural problems.
6. Analyze the dynamic behavior of structure using FEM.

Prerequisite: Engineering Mathematics, Mechanics of Materials, and Heat Transfer

Course Content:

Unit No.	Description	Hrs.
1.	**Introduction-** Basic idea of FEM –Discretization, -element types, selection of elements, no of elements, node numbering scheme, Interpolation models- Compatibility and completeness requirement. Linear and higher order elements, selection of interpolation polynomial, global natural and local coordinate system. Weighted residual methods- Galerkin method. Variational formulation	06
2.	**Analysis of vector field problems** Formulation of finite element equation for structural problems, one, two and three dimensional structural analysis. Assembly and solution of finite element equations. Analysis of truss structure. Temperature effect analysis. Axisymmetric structural analysis.	06
3.	**Analysis of scaler field problems** General finite element formulation of scaler field problems, one, two and three dimensional heat transfer analysis. Axisymmetric thermal analysis, Torsion analysis.	06
4.	**Isoparametric formulation.** One and two dimensional higher order elements, isoparametric elements, evaluation of finite element equation for higher order elements, numerical	06

	integration, Lagranges interpolation polynomial.	
5.	**Bending of Beam and plates** Harmite interpolation polynomial, beam element, structural beam analysis. Axisymmetric element. Bending of thin plates, analysis of shells	06
6.	**Dynamic analysis using finite elements.** Equation of motion based on weak form. Axial vibration of bar, transverse vibration of beam. Consistent element mass matrix and lumped mass matrix. Nonlinear analysis.	06

References:

1. Rao S. S., "Finite Elements Method in Engineering"- 4th Edition, Elsevier, 2006.
2. P. Seshu, "Finite Element Analysis" Prentice hall of India, 2006.
3. Robert D Cook "Concepts and applications of finite element analysis" 4th edition John Wiley & Sons.
4. David V Hutto, "Fundamentals of Finite element analysis" Tata McGraw Hill.
5. Frank L. Stasa," Applied finite Element Analysis for Engineers", CBS International Edition, 1985.
6. J. N. Reddy, "Finite Element Method"- McGraw -Hill International Edition.

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Advanced Mathematical Methods in Engineering** Course Code:**SH513**

L	T	P	Credits
3	-	-	3

Course Description:
This course intends to build the competency in the students to apply the knowledge of mathematics to the solution of engineering problems and to analyze it.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Evaluate Fourier series and Fourier Transforms for given function and apply it to solve the partial differential equations in Engineering problems.
2. Apply the specific method of solution of partial differential equations for solving the given problems.
3. Formulate and solve a boundary value problem (Partial differential equation, boundary.
4. Use the relevant method for solving the simultaneous linear equations and compute the Eigen values.
5. Estimate numerically the solution of given algebraic equation.
6. Analyse the variance and explain the different research designs.

Prerequisite: Engineering Mathematics

Content:

Unit No.	Description	Hrs.
1.	**Fourier Series and Fourier Transforms** Fourier series: The Fourier series of a function, Convergence of a Fourier series, Fourier Cosine and Sine series, Integration and differentiation of Fourier series. The Fourier Integral, The Fourier Cosine and Sine Integrals, The Complex Fourier Integral and the Fourier Transforms, Inverse Fourier Transforms.	06
2.	**Partial Differential Equations** First order partial differential equations; Second order linear partial differential equation: Canonical forms: Second order equation (Parabolic, Elliptic and Hyperbolic) in rectangular, cylindrical, polar and spherical coordinate systems; Solution techniques: Separation of variables, Eigen function expansions.	06
3.	**Applications of Partial Differential Equations** The wave Equation and Initial and Boundary Conditions, Fourier Series solution of the wave equation, Fourier Transform Solution of Problems on Unbounded Domains, Characteristics and D'Alembert's Solution: D'Alembert's solution for the wave equation, A non-homogeneous wave equation, Forward and backward waves, Normal modes of vibration of a	06

	circular elastic membrane, Vibration of rectangular membrane.	
4.	**Simultaneous Linear Equations** Gaussian Elimination method, Gauss Jordan method, LU- decomposition from Gaussian Elimination method, Eigen Value problems,Solution of Tridigonal Systems.	06
5.	**Numerical Methods** Muller's Method, Horner's Method, Multiple roots, Lin Bairtow's Method, Graeffe's Squaring Method.	06
6.	**ANOVA** One-way, Two-way with/without interactions, ANOVA technique, Principles of Design of Experiment: Some standard designs such as Latin-Square Design (LSD), Completely Randomized Design (CRD), Randomized Block Design (RBD).	06

References -

1. Larry C. Andrews, Ronald L. Phillips, Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Private Ltd. New Delhi, ISBN-81-203-2826-14, 2005.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Eastern, NEW DELHI, Tenth Edition, 2010.
3. J. B. Doshi, Differential Equations for Scientients and Engineers, Narosa 2010.
4. Peter O'Neil, Advanced Engineering Mathematics, Seventh Edition, Cengage Learning 2012 (Indian Edition).
5. Michel Greenberg, Advanced Engineering Mathematics, Second Edition, Pearson's Education, 2002 (Indian Edition).
6. Ramamurthy. V., Computer Aided Design in Mechanical Engineering, Tata McGraw Hill Publishing Co., 1987.
7. Fundamental Concepts in the Design of Experiments, 5th Ed., by Hicks and Turner.
8. Devore, Jay L., Probability and Statistics for Engineering and the Sciences, 5th Edition, Brooks- Cole (1999).

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Vehicle Dynamics** Course Code: **MAE2010**

L	T	P	Credits
3	1	-	4

Course Description:
The course is very much essential for concrete understanding of vehicle performance evaluation and predictions. This course is highly recommended for students aiming to make carrier in Vehicle Evaluation and Testing and Vehicle Design. Being analytical in nature, the course demands knowledge of mathematics (Calculus). The student should have taken courses in Automotive Chassis and Machine Dynamics earlier as this will facilitate comprehension of course content. This course enables the student to evaluate vehicle performance when provided with the required data and also prepares him to undertake research projects in the domain of automotive engineering.

Course Outcomes:
After completion of this course student will be able to
1. Calculate axle loads under any combination of accelerations, grades, aerodynamic forces etc.
2. Evaluate vehicle acceleration performance in the light of engine power constraint and traction limit constraints.
3. Determine braking performance of vehicle over the range of operating conditions.
4. Evaluate response of vehicle to steering inputs at low and high speeds and its characterization as understeer or oversteer.
5. Estimate ride performance of a vehicle in terms of resonant frequencies, bounce and pitch frequencies.

Prerequisite: Automotive Systems, Theory of Machines.

Content

Unit No	Description	Hrs
1.	**Performance Characteristics of Vehicle** Equation of motion and maximum tractive effort. Aerodynamics forces and moments. Power plant and transmission characteristics. Prediction of vehicle response to braking, crashworthiness of a vehicle.	06
2.	**Longitudinal Dynamics** Vehicle Load Distribution – Acceleration and Braking - Brake Force Distribution, Braking Efficiency and Braking Distance - Longitudinal dynamics of a Tractor-Semi Trailer.	06
3.	**Tire Mechanics** An Introduction, Mechanical Properties of Rubber - Slip, Grip and Rolling Resistance - Tire Construction and Force Development - Contact Patch and Contact Pressure Distribution.	06
4.	**A Simple Tire Model** Lateral Force Generation - Ply Steer and Conicity - Tire Models – Magic	06

	Formula - Classification of Tire Models and Combined Slip.	
5.	**Lateral Dynamics** Bicycle Model - Stability and Steering Conditions - Understeer Gradient and State space Approach – Handling Response of a Vehicle - Mimuro Plot for Lateral Transient Response - Parameters affecting vehicle handling characteristics.	06
6.	**Vertical Dynamics** Rollover Prevention - Half Car Model - Quarter Car Model, Noise, Vibration and Harshness – Random Processes.	06

References –

1. Gillespie T. D., 'Fundamentals of Vehicle Dynamics', SAE International.
2. Wong J. Y., 'Theory of Ground Vehicles', Willey & Sons.
3. Pacejka H. B., 'Tyre and Vehicle Dynamics', Butterworth Hienmann.
4. Jazar, Reza N. Vehicle dynamics: theory and application. Springer, 2008.
5. N. K. Giri, 'Automotive Mechanics', Khanna Publishers (9th Edition).
6. Moore, Desmond F. "The friction of pneumatic tyres." (1975).
7. G. Genta, 'Motor Vehicle Dynamics', World Scientific.
8. Rajamani Rajesh, 'Vehicle Dynamics and Control', Springer.

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Design of Electric and Hybrid Electric Vehicles** Course Code:**MAE2020**

L	T	P	Credits
3	-	-	3

Course Description:
With depleting conventional fuel sources, modern transportation cannot rely on only IC Engine powered vehicles. Electric and Hybrid electric vehicle technology is poised to grow in the current and next decade. There are already many EVs and HEVs on roads of developed nations and are being offered as viable means of transportation in developing countries as well. Govt. of India has already taken policy initiatives like NEMMP and FAME to promote this technology on Indian roads and expressed intentions to electrify the vehicles on Indian roads by 2028. With many international OEMs entering into the Indian market, independently or with joint collaboration with Indian entity, many employment opportunities in the domain of design, research and testing are expected to be created in this area of automotive industry.
The main focus of the course is on design and modelling of Electric and Hybrid Electric Vehicles. As a part of this design, the students are exposed to various aspects of electric drivetrain like electric drives and battery selection criteria, various configurations of EVs, architectures of HEVs, series and parallel HEVs and Fuel cell technology for road vehicles. The course offers an opportunity for students to learn a modern and relevant technology as a part of the program.

Course Outcomes:
After completion of this course student will be able to
1. Appreciate the relevance of EVs and HEVs for road transportation.
2. Design an EV for given requirements and estimate its performance.
3. Design an HEV in terms of architecture, control strategy and various elements for said requirements.
4. Describe the fuel cell technology and model the FCEV for the road application.

Prerequisite: Basics of Mechanical Engineering, Automotive Systems, Electrical Drives and Control

Content

Unit No	Description	Hrs
1.	**Introduction and overview** Environment impact, history of EVs, market scenario, conventional drive train elements, formats and design principles.	06
2.	**Electric vehicles - technology and design** Configurations of EVs, design process and issues, modelling and performance estimation, energy consumption, regenerative brakes.	06
3.	**Hybrid electric vehicle technology** Concept, modes and patterns, architectures of hybrid drive trains, series hybrid drive train, parallel hybrid drive train with torque coupling and speed	06

	coupling.	
4.	**Design of series and parallel hybrid drive trains** Operation patterns, design objectives, control strategies, sizing of components, parametric design.	06
5.	**Peaking power sources and drives for EVs** Electrochemical batteries, charging of batteries, battery management, ultra-capacitors, ultra-high-speed flywheels, electric motors used for EVs and HEVs like dc motors, induction motors, SRM etc.	06
6.	**Fuel Cell Electric Vehicle drive train design** Fuel cell technology, PEM and direct methanol fuel cell, drive train design for FCVs.	06

References –

1. Robin Hardy, Iqbal Husain, 'Electric and Hybrid Vehicles', CRC Press, ISBN 0-8493-1466-6.
2. Mehrdad Ehsani, Yimin Gao, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles – Fundamentals, Theory and Design', CRC Press, New York, 2010.
3. James Larminie, John Lowry, 'Electric Vehicle Technology Explained', John Wiley & Sons Ltd., England, 2003.
4. Iqbal Hussain, 'Electric & Hybrid Vehicles – Design Fundamentals', CRC Press, New York, 2003.
5. Sandeep Dhameja, 'Electric Vehicle Battery Systems', Newnes, Massachusetts, 2002.
6. Dr Mike Westbrook, M H Westbrook, 'The Electric Car: Development & Future of Battery, Hybrid Cars', British library Cataloguing in Publication Data, UK, ISBN0 85296 0131.

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Technical Communication** Course Code: **SH551**

L	T	P	Credits
2	-	-	Audit

Course Description:
This course aims to develop skills of students to produce clear and effective scientific and technical documents. This focuses on basic principles of good writing-which scientific and technical writing shares with other forms of writing-and on types of documents common in scientific and technical fields and organizations. While the emphasis will be on writing, oral communication of scientific and technical information is included as an important component of the course, as well.

Course Outcomes:
After completion of this course student will be able to
1. Acquire skills required for good oral and written communication.
2. Demonstrate improved writing and reading skills.
3. Ensure the good quality of oral and written communication.

Prerequisite: NIL

Content

Unit No	Description	Hrs
1.	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.	04
2.	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism.	04
3.	Sections of a Paper, Abstracts, Introduction, Review of the Literature, Methods, Results, Discussion, Conclusions, and the Final Check.	04
4.	Key skills needed when writing a Title, key skills needed when writing an Abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature.	04
5.	Key skills needed when writing the Methods, skills needed when writing the Results, skills needed when writing the Discussion, skills needed when writing the Conclusions, useful phrases, how to ensure good quality of the paper at the time of submission.	04
6.	Resume Writing, e-Mails, Interview skills, Dos and Don'ts while Answering, FAQs, Group Discussion: Structured and Unstructured GD, Opening and Closure, Showing Agreement and Disagreement.	04

References –
1. Goldbort R ,Writing for Science, Yale University Press (available on Google Books), 2006.
2. Day R , How to Write and Publish a Scientific Paper, Cambridge University Press, 2006.

3. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book, 1998 .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.
5. John Seely, Oxford Guide to Effective Writing and Speaking; Oxford University Press, 2009.
6. Thomas N. Huckin and Leslie A. Olsen, Technical Writing and Professional Communication for Nonnative Speakers of English; Tata McGraw Hills, International Edition, 1991.
7. Jeff Butterfield, Soft Skills for Everyone, Cengage Learning India Private Limited, 2010.

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **CFD Laboratory** Course Code: **MAE2130**

L	T	P	Credits
-	-	4	2

Course Description:
In today's rapidly changing world, CFD has become predominant in almost every stream of design and manufacturing industry. For the engineers who aspire to work in such industries or allied research, CFD knowledge is considered to be a must. This course develops the skills sets in meshing and simulation of fluid dynamics and heat transfer problems. This is highly recommended course for passionate engineer willing to pursue CFD as a career. The most critical obstacle toward learning CFD is the fundamental knowledge and high level of expertise in software usage. The objective of the course is not just to make an expert software user but to inculcate a thinking of how to use CFD as a design tool. For achieving this goal, more focus is given to all the advanced simulations of complex physics like heat transfer, multiphase flows and rotating machinery applications.

Course Outcomes:
After completion of this course student will be able to
1. Select appropriate domain for CFD simulation.
2. Select suitable meshing technique for CFD simulation
3. Apply proper domain and boundary conditions.
4. Simulate steady state and transient fluid flow and heat transfer problems.
5. Simulate multiphase flow problems.
6. Use CFD results for making design decisions.

Prerequisite: Fluid Mechanics and Machinery, Heat Transfer

Content
In this course, training on any one of the following software will be provided to the students.
1. ANSYS
2. Hyper works
3. ABAQUS

Course Content
1. CFD Analysis – The Software Perspective.
2. Geometry creation
3. Meshing.
4. Solver basics and user interface.
5. Turbulence modeling,
6. Boundary and Cell Zone conditions,
7. Solver Mathematics and Post Processing,
8. Heat transfer simulation
9. Multiphase flow modeling.
10. Discrete Phase model (DPM).
11. CFD of Rotating Machinery flows

References –

1. H. K. Versteeg, W. Malalasekera, an Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education (Indian Edition).
2. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor and Francis (Indian Edition).

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Mini-Project** Course Code: **MAE2140**

L	T	P	Credits
-	-	4	2

Course Description:
Innovation is a key requirement for any good research. This course offers opportunity for the students to demonstrate creativity and transform a simple, small idea into a working prototype or model. The course provides an exposure towards problem solving as well as teamwork and make them industry-ready. The course also helps enhancing presentation and technical writing skills of the students and addresses multiple Program Outcomes.

Course Outcomes:
After completion of this course student will be able to
1. Identify a problem of small magnitude preferably in automotive domain.
2. Analyze the problem with certain objectives and within applicable constraints.
3. Offer/Suggest/Implement innovative solution to the said problem and validate the solution.
4. Communicate the effort through presentation, display and technical report.

Prerequisite: Nil.

Content
The student/s will have to identify a problem of small magnitude in consultation with the supervisor within first four weeks. He/She/They should analyse the problem from different perspectives and carry out literature review or patent search. Based on the analysis, student/s should offer and implement solution to the chosen problem. Extensive analyses and insights gained from interpretations based on this analysis, which leads towards the future solutions can be fulfill the requirement of Mini-project. A physical prototype/model though is preferred as a solution, a design document, CAD model, mathematical model, theoretical framework for problem solution, simulation model are also acceptable as a part of solution. The originality and innovativeness of the work should be given consideration while evaluating the effort.

Guidelines for Mini Project:
1. One faculty member is allotted for every student or a batch of two students.
2. A problem definition to be submitted by the student/team within FOUR weeks to the supervisor with one copy to the HoP.
3. A mid-semester presentation shall be organized by the HoP for tracking the progress.
4. The Mini-project shall be evaluated by the supervisor along with the DPGC members based on a rubric.

Program Elective III

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Heating, Ventilation and Air Conditioning** Course Code:**MAE2030**

L	T	P	Credits
3	-	-	3

Course Description:
This is an era of luxurious automobiles where market demands more comfort and safety. When we focus on comfort, ventilation and air-conditioning share is more. Refrigeration in transport Vehicle plays a vital role for carrying goods far away with same quality, without changing its environmental conditions or by freezing/deep freezing the goods. With this concern automotive heating, ventilation and air-conditioning course may add value and develop skills which are listed in CLOs.

Course Outcomes:
After completion of this course student will be able to
1. Design Refrigeration system for Refrigerated Vehicle.
2. Apply psychometric concepts (like comfort) in design of HVAC of an automobile.
3. Analyse Automotive HVAC system.
4. Explain troubleshooting methods and maintenance of automotive HVAC system.

Prerequisite: Applied Thermodynamics

Content

Unit No	Description	Hrs
1.	**Fundamentals of Automotive Refrigeration and Air Conditioning** Basic Refrigeration and air conditioning types, refrigerant types (Automotive refrigerants) and selection, Modes of Refrigeration in refrigerated transport vehicle, Schematic layout of a refrigeration system - Transport refrigeration. Layout of Air conditioning system, Location of air conditioning components in a car.	06
2.	**Components of Automotive HVAC and Climate Control** HVAC unit, Compressor, Condenser and high-pressure Service ports, AC tubing, Thermostatic expansion valve. Controlling Evaporator Temperature (modes of control), Controlling Circuits-Air Circuits & Refrigerant circuits & Electrical circuits etc. Insulation in car air conditioning and refrigerated vans and carriers.	06
3.	**Air conditioning -Heating System** Introduction to Automotive heating system layout, Schematic study, Principle of Operation of Cabin Heater. Heater sizing calculations, Heater design Guidelines. Common Failures and diagnostics. Air conditioning protection – Engine protection, Magnetic clutches belt driven systems and independent engine driven systems.	06

4.	**Psychometric and Load Calculation** Comfort, Factors forming the load on refrigeration & air conditioning systems - Cooling & heating load calculations - Load calculations for automobiles - Effect of air conditioning load on engine performance, Effects of direct solar radiations and air velocity on the load estimation. Estimation of cooling down time (cool down curves, heat up curves).	06
5.	**Air Routing and Temperature Control** Objectives, Evaporator care air flow Through the Dash Recirculation Unit, Automatic temperature control, Duct system, controlling flow, Vacuum reserve, Testing the air control and handling systems (descriptive treatment only).). Quick cooling and air recirculation systems. Air distribution systems in various types of passenger and transport vehicles.	06
6.	**Air conditioner maintenance and Service** Servicing heater systems removing and replacing components, Refrigerant leak detection methods Trouble shooting of air conditioning systems, Compressor Service. Preventive maintenance, Performance Testing and Validation of HVAC System at Vehicle level.	06

References –

1. Steven Daly, "Automotive Air Conditioning and Climate Control Systems", Butterworth-Heinemann; 1st edition, 2006.
2. Boyce H. Dwiggins, "Automotive Air Conditioning" S.Chand (G/L) & Company Ltd; 8th Revised edition.
3. Norman C. Harris, "Modern Air-Conditioning Practice", McGraw-Hill Education 1984.
4. Paul Lung, "Automotive Air Conditioning", C.B.S. Publisher & Distributor, Delhi,1991.
5. W.F. Stoecker and J.W. Jones, "Refrigeration and Air-Conditioning", Tata McGraw Hill Pub, 1982.
6. William.H.Crouse, Donald.L.Anglin, Automotive Air Conditioning, McGraw Hill, 1990.
7. Tom Birch, Automotive Heating and Air conditioning, Prentice Hall, 2003.
8. Mitchel Information Services, Inc., Mitchell Automatic Heating and Air Conditioning Systems, Prentice – Hall, Inc., 1989.
9. Paul Weisler, Automotive Air Conditioning, Reston Publishing Co., Inc., 1990.

Program Elective-III

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Special Purpose Vehicles** Course Code: **MAE2040**

L	T	P	Credits
3	-	-	3

Course Description:
The main objective of this course is to introduce the concept and principle of operation of special purpose vehicles such as loaders, bulldozers, excavators, backhoe loaders, scrappers, and motor graders, farm equipments, etc. At the end of the course, the students can have a better understanding of the application of the special types of vehicles in the excavation of earth.

Course Outcomes:
After completion of this course student will be able to
1. Describe the construction & working of stratified charged/lean burn engines.
2. Describe the working of power trains in special propose vehicles and able to analyze the ride characteristics.
3. Describe the working of drive line in special propose vehicles and compared with commercial vehicles.
4. Describe the construction of farm equipments.
5. Apply the safety concepts for design special proposes vehicles.

Prerequisite: Basics of Mechanical Engineering.

Content

Unit No	Description	Hrs
1.	**Earth Moving and Constructional Equipments:** Construction layout, capacity and applications of earthmovers for dumpers, front-end loaders, bulldozers, excavators, backhoe loaders, scrappers, and motor graders etc. criteria for selection of prime mover for dumpers and front end loaders based on vehicle performance characteristics.	06
2.	**Powertrain Concepts:** Engine – converter match curves. Epicyclical type transmissions. Selection criteria for universal joints. Constructional details of steerable and drive axles of dumper.	06
3.	**Vehicle Systems and Features:** Brake system and actuation – OCDB and dry disc caliper brakes. Body hoist and bucket operational hydraulics. Hydro-pneumatic suspension cylinders. Power steering system. Safety features, safe warning system for dumper. Design aspects on dumper body and loader. Articulated vehicles, Firefighting equipment.	06
4.	**Earth Moving Machines:** Construction and operation aspects of Bull dozers, Scrapers, Dumpers, Loaders, Mobile cranes, Road rollers, Elevators and Elevating graders.	06
5.	**Special Purpose Vehicles for Industrial Applications:**	06

	General description, specification and functions, fork lift trucks, Scissors lift trucks - applications in industry, advantages and disadvantages. Constructional features, capacity and stability of jib cranes. Vibratory compactors. Stackers bore well machines, concrete mixtures.	
6.	**Farm Tractors:** Tractors: General description, specification and functions, light, medium and heavy wheeled tractors, crawler tracks mounted / wheeled-bull dozers, tilt dozers and angle dozers, front end loaders, factors affecting efficiency of output of tractors, simple problems, merits and demerits.	06

References –

1. Sharma, S.C., "Construction Equipment and its Management".
2. Nakra C.P., "Farm Machines and Equipments", Dhanparai Publishing company Pvt. Ltd. 2003.
3. Wong J Y, "Theory of Ground Vehicles", John Wiley and Sons, New York, 1978.
4. Satyanarayana. B., "Construction Planning and Equipment", Standard Publishers and Distributors, New Delhi.
5. Pipenger, "Industrial Hydralics", Mcgraw Hill, Tokoyo, 1979.
6. Astakhov, "Truck Cranes", MIR Publishers, Moscow, 1971.
7. Bart H., Vanderveen, "Tanks and Transport Vehicles", Frederic Warne and Co. Ltd., London, 1974.
8. K. Abrosimov, A. Bromberg and F. Katayer, "Road Making Machineries", MIR Publisher, Moscow,1975.
9. SAE Handbook – Vol III, 1995.

Program Elective-III

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Farm Equipments and Machinery** Course Code: **MAE2050**

L	T	P	Credits
3	-	-	3

Course Description:
Farm machinery significantly decreases the time required for farmers to accomplish farm tasks. For instance, using a tractor and plough, a farmer can plough in several hours a field that would take him an entire day to till had he done it using a horse-pulled plough. Farm machinery decreases the need on farms for farm workers. Rather than spending money to pay salaries for multiple employees, the modern farmer uses his financial resources to purchase and maintain farm equipment.

Course Outcomes:
After completion of this course student will be able to
1. Classify farm machinery and their operation, on tillage, sowing, plant protection, harvesting and threshing machinery
2. Understand proper measures for care and maintenance of agricultural machinery
3. Select appropriate lubrication system for farm equipments.
4. Explain the dismantling and reassembling of a disc harrow, seed-cum fertilizer drill and sprayer and engine pumps
5. Understand the various equipments and mechanizations used in the farm
6. Knowledge on earth moving machineries, tractor classification and tillage implements.

Prerequisite: Basics of Mechanical Engineering, Automobile Chassis Systems, Automotive Transmission.

Content

Unit No	Description	Hrs
1.	**Tractor and Power Tiller** Tractors - identification of major systems - components and their uses. Types of hitch systems and adjustments. Preliminary checkups and safety aspects before starting a tractor and power tiller - procedure for starting, running and stopping the tractor and power tiller - driving tractor and power tiller on road and field.	06
2.	**Tillage Equipments** Primary Tillage Equipment - Mould board plough - animal and power operated, types and construction, working principles. Accessories of M.B. plough - forces acting on mould board bottom. Disc ploughs, types and construction, soil reaction and draft of disk ploughs, and special tillage implements such as rotavators sub-soiler, paddy puddler Secondary Tillage Equipment - Disc harrow - types and construction - Selection.	06
3.	**Dynamics and Hitching of Farm Equipments**	06

	Dynamic soil properties affecting soil tool interaction. Atterberg, soil and metal friction - Force analysis of tillage tools and their measurement. Types of dynamometer-spring hydraulic, eddy current and strain gauge types - Virtual and real hitching for single point, single axis and double hitch implements - Yokes and harness for draught animals and mechanics of hitching.	
4.	**Equipments for Other Farm Operations** Construction and working principles of sowing / seeding, planting and fertilizer application equipment, seed and fertilizer metering devices, furrow openers and covering devices, calibration, field adjustment and operations, paddy planters - Interculture Equipment - Cultivators, sweeps and shovels, types and uses, rotary hoes, nodders, classification of weeders according to power sources - Plant protection equipments, types construction and working principle. Selection of equipment for spraying and dusting - Safety aspects.	06
5.	**Equipments for Special Farm Operations** Harvesting and Threshing - Classification, construction and working principles of reapers mowers, combine harvesters and power threshers - Specialized Crop Equipment for maize, cotton, sugarcane, root crops and horticultural crops. Selection of Farm Machinery - Performance evaluation, cost analysis and management of farm equipment. Ergonomics studies and safety of Farm Machinery & Equipment.	06
6.	**Servicing and Repairing of Farm Equipments** Checking vehicle for repair, General vehicle service & routine maintenance checks. Fault tracing, various farm tractors tools, tractor dismantling, engine stripping, vehicle peripherals & reassembly. Job card Preparation. Servicing for basics performance haulage farm operations, Steering, Brakes, Clutch & Hydraulic Testing. Introduction power tiller, Need for testing & evaluation of farm tractor, Types of test procedure, test codes for performance of tractor & power tiller.	06

References –

1. Jain, S.C. and C.R. Rai, Farm Tractor Maintenance and Repair, Standard Publishers and distributors, New Delhi, 1999.
2. S. C. Sharma, 'Construction Equipment and its Management', Khanna Publisher. Sixth Edition, 2015.
3. Herbert L.Nichols Sr.. Moving the Earth, D. Van Nostrand Company Inc., Princeton, 1959.
4. Barger, E.L., J.B. Liljedahl and E.C. McKibben, Tractors and Their Power Units, Wiley Eastern Pvt. Ltd., New Delhi, 1997.
5. John A Havers and Frank W Stubbs, Hand book of Heavy Construction, Mc Graw – Hill book Company, New York, 1971.
6. Gary Krutz, Lester Thompson and Paul Clear., "Design of Agricultural Machinery", John Wiley and Sons, New York, 1984.
7. Srivastava A.K., Goering.C.E, Rohrbach R.P, Engineering Principles of Agricultural Machines. Revised Printing by American Society of Agricultural Engineers, 1993.

8. Bosoi, E.S., Theory, Construction & Calculation of Agricultural Machines, Volume 1 and 2, Oxonion Press Pvt. Ltd., New Delhi, 1990.
9. Habibulla, Sri Shali, Farm Equipment and Tractors, Department of Rural Engineering Technician-State Institute of Vocational Education, Directorate of Intermediate Education, Govt. of Andhra Pradesh, Hyderabad.

Program Elective-III

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Automotive Aerodynamics** Course Code: **MAE2060**

L	T	P	Credits
3	-	-	3

Course Description:
The main objective of this course is to introduce the concept and principle of fluid mechanics, definitions, aerodynamics of car, different shapes of car, lift and drag analysis, wind tunnel testing etc. This study provide the students with basic principles of aerodynamics for the design of vehicle body with main goals to reduce vehicle drag, minimizing noise emission and undesired lift forces and other causes of aerodynamic instability at high speeds.

Course Outcomes:
After completion of this course student will be able to
1. Apply basic principles of aerodynamics for the design of vehicle body.
2. Calculating lift and drag of automotive models
3. Describe the physics of fluid flow over vehicle body and its optimization techniques.
4. Use of wind tunnels in testing the vehicles.
5. Apply computational fluid dynamics (CFD) tool for aerodynamics study.

Prerequisite: Fluid Mechanics and Machinery

Course Content

Unit No	Description	Hrs
1.	**Introduction** Scope – historical development trends – Fundamentals of fluid mechanics – Flow phenomenon related to vehicles – External & Internal flow problems – Resistance to vehicle motion – Performance – Fuel consumption and performance – Potential of vehicle aerodynamics.	06
2.	**Aerodynamic drag of cars** Cars as a bluff body, Flow field around car, Aerodynamic drag and its types, various forces and moments & its effects on performance, analysis of aerodynamic drag, drag coefficient of cars, strategies for aerodynamic development for low drag profiles.	06
3.	**Stability, safety & comfort** The origin of forces and moments on a vehicle, side wind problems, methods to calculate forces and moments, vehicle dynamics Under side winds, the effects of forces and moments, Characteristics of forces and moments, Dirt accumulation on the vehicle, wind noise, drag reduction in commercial vehicles. Wind noise, Air flow around individual components, High performance vehicles, Design alternatives, High efficiency radiator arrangement.	06
4.	**Shape optimization of car** Front end modification, front and rear wind shield angle, Boat tailing, Hatch	06

	back, fast back and square back, air flow patter around individual component, Dust flow patterns at the rear, Effects of gap configuration, effect of fasteners.	
5.	**Wind Tunnels for automotive Aerodynamics** Introduction - Principle of wind tunnel technology, Limitation of simulation, measuring equipment and transducers, Pressure measurement, velocity measurements, Flow visualization techniques, Road testing methods.	06
6.	**Computational Fluid Dynamics (CFD)** Introduction to governing, Solution methodology, desertification technique, Post processing of results, BC solution methods, CFD preprocessing, and post processing techniques, Diff plots.	06

References –

1. Wolf – Heinrich Hucho, Aerodynamics of Road Vehicles, SAE, ISBN No: 978-0-7680-0029-0, 1998.
2. Pope. A., Wind Tunnel Testing, John Wiley & Sons, 2nd edition, New York, 1974.
3. McCallen, Browand, Ross, "The Aerodynamics of Heavy Vehicles", Springer, 2004.
4. Ino Sovran, Vehicle Aerodynamics, SAE, 1994.
5. Automotive Aerodynamic: Update SP-706, SAE,1987.
6. Vehicle Aerodynamics - SP-1145 – SAE, 1996.

Program Elective-III

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Automotive Emissions and Control Technology** Course Code:**MAE2070**

L	T	P	Credits
3	-	-	3

Course Description:
The engine emissions are unwanted products of engine combustion. The syllabus focuses on the way engine combustion influence formation and emission of pollutants. Unit 1 presents the processes that cause formation of pollutants and the influence of different engine design and operational parameters on emission based on the extensive knowledge existing in the published literature on the course is discussed. A brief review of worldwide emission standards, test procedures and measurement methods are discussed in Unit 2. It is followed be discussions on the methods and technologies being used for engine emission control in Unit 3 &4. Newer developments such as gasoline direct injection (GDI), direct injection stratified charge (DISC) and homogeneous charge compression ignition engine (HCCI) are also discussed. The modern emission controlled engine demand improved fuels and hence, the conventional petroleum fuels and the prospective alternative fuels are discussed in Unit 5 & 6.

Course Outcomes:
After completion of this course student will be able to
1. Outline the overview of emission control technologies in SI engine.
2. Explore effect of engine design parameters and engine operating variables on SI engines.
3. Analyse the pollutant formation mechanisms in IC engine emissions.
4. Illustrate the knowledge of emission norms, standard test procedures and emission measurements techniques.
5. Analyse different emission control technologies in IC engines.

Prerequisite: Engineering Chemistry and I. C. Engines.

Content

Unit No	Description	Hrs
1.	**Formation of Engine Emissions:** Emission effects on health and environment, photochemical smog, sources of engine emission, formation of carbon monoxide, NO formation, UBHC formation, Soot and PM formation, Diesel NOx- Particulate Trade off, Effect of SI & CI engine design and operating variables.	06
2.	**Emission standards and measurement:** Emission standards, Emission test cycles, Emission measurement Instrumentation and method, NDIR analyzer, FID, Chemiluminscence analyzer, smokemeters, constant volume sampler, particulate emission measurement.	06
3.	**SI Engine Emission control technology:** SI engine design parameters, Add on systems for treatment of emissions	06

	within engine, PCV system, Evaporative emission control, Exhaust Gas Recirculation, Exhaust aftertreatment, Direct Injection Startified Charge Engines.	
4.	**CI Engine Emission control technology:** CI Engine Design parameters, Application of EGR in CI engines, Exhaust After treatment in diesel engines, Diesel oxidation catalysts, De-NOx Catalysts, DPF, Regeneration of DPF, Partial DPF, HCCI engine for emission control.	06
5.	**Engine Fuels and Emissions:** Common Hydrocarbon components, General Fuel Quality Requirements, Motor Gasoline: Octane Quality, Distillation Range, Reid Vapor pressure, oxidation stability and deposit control, hydrocarbon composition, sulphur content, oxygenates, other properties and contaminates, reformulated gasoline, development of international gasoline specifications. Diesel fuels: Ignition quality, distillation range, density, viscosity, oxidation and storage stability, chemical composition, sulphour content, lubricity, Trend in diesel fuel types.	06
6.	**Combustion Diagnostics:** In cylinder pressure measurement, Optical research engines, flow field studies, spray structure and drop size distribution, engine combustion visualization, combustion species and temperature, OH, CH and No, Soot.	06

References –

1. B. P. Pundir, "Engine Emissions", Narosa Publications, 2012.
2. V. Ganesan, Internal Combustion Engines, Tata McGraw Hill, 1994.
3. W. M. Crouse, A. L. Anglin, Automotive Emission Control, McGraw Hill, 1995.
4. G. S. Springer, D. J. Patterson, Engine Emission & Pollutant Formation, Plenum Press, 1986.
5. D. J. Patterson, N. A. Henin, Emissions from Combustion Engines & their Control, Ann Arbor Science, 1985.
6. W. M. Crouse, A. L. Anglin, Automotive Emission Control, McGraw Hill 1995.
7. Paul Degobert- Automobiles & Pollution- SAE International ISBN- 1-56091-563-3.

Program Elective - IV

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Manufacturing Systems Design** Course Code: **MAE2080**

L	T	P	Credits
3	-	-	3

Course Description:
Manufacturing systems converts raw material to finished product for customer usage. Manual operations have limitations in terms of power, precision and repetitions. Recent techniques / electronics devices provide precision machine control compare to conventional machines. Objective of leaning this subject is to make aware the students about the advance manufacturing practices being implemented at leading industries across the globe, which ultimately leads to more customer satisfaction in terms of low cast and high quality.

Course Outcomes:
After completion of this course student will be able to
1. Describe the fundamental concepts of manufacturing systems.
2. Design process planning for given product.
3. Prepare layout for manufacturing system.
4. Optimize manufacturing system.
5. Explain modern approaches of manufacturing.

Prerequisite: Automotive System Design, Control Engineering.

Content

Unit No	Description	Hrs
1.	**Fundamentals of Manufacturing Systems** System concept, System design, Decision making procedure, System types in manufacturing environments, Manufacturing Systems: Structural aspects, transformational aspects, procedural aspects, integrated manufacturing systems; Modes of Production- Jobbing/Intermittent/ Continuous; Mass Production- Economies of Scale, Optimum production scale, Mass Customization; Multi-Product Small Batch Production- Economies of Scope with Diversification; Logistic Systems- Material flow: conversion / transportation / storage.	06
2.	**Product / Process Planning and Design** Product Life Cycle, Planning of a new product, Product Design Aspects, Design cost considerations, Concurrent Engineering; Process and Operation Design, Process Planning and Design, Optimum routing analysis using Dynamic Programming and Network Techniques, Criteria for line balancing.	06
3.	**Layout & Logistic Planning and Design** Microcontroller: Scope, Systematic layout planning, Mathematical layout design, Product flow analysis, Transportation problems, Distribution problems.	06

4.	**Manufacturing Optimization** Criteria for Evaluation, Optimization of single stage manufacturing- Unit production time and cost; Optimization of multistage manufacturing system- Scope, basic mathematical models; Cost Estimating- Classical metal cutting cost analysis, Industrial cost estimation practices, Estimating material, setup and cycle times.	06
5.	**Flexible Manufacturing System (FMS)** Major elements of FMS and their functioning: Tool handling system, Material handling system, Automated guided vehicles, automated storage and retrieval system, Main frame computer, FMS layout - concept, types and applications, Data required developing an FMS layout, FMS layout design.	06
6.	**Modern approaches in Manufacturing** Cellular Manufacturing- Group Technology, Composite part, Rank Order Clustering Technique, Hollier method for GT cell layouts; Flexible Manufacturing- Concept, components, architecture; Lean Production concept, principles, Agile Manufacturing- concept, principles and considerations for achieving agility.	06

References –

1. Katsudo Hitomi, 1998, "Manufacturing Systems Engineering", Viva Low Priced Student Edition, ISBN 81-85617-88-0.
2. Mikell P. Groover, (2002), "Automation, Production Systems and Computer Integrated Manufacturing", (2/e), Pearson Education, ISBN 81-7808-511-9 3)
3. N. Viswanadhan & Y, Narhari, 1998, "Performance Modeling of Automated Manufacturing Systems", Prentice Hall of India
4. Phillip F. Ostwald, Jairo Munez, 2002, " Manufacturing Processes and Systems", John Wiley & Sons (Students' Edition), ISBN 9971-512-34-3
5. Sanjay B. Joshi, Jeffrey S. Smith, 1994, "Computer Control of Flexible Manufacturing Systems: Research and Development", Springer, ISBN 0412562006, 9780412562006.

Program Elective - IV

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **I**
Course: **Mechanics of Composite Structure** Course Code: **MAE2090**

L	T	P	Credits
3	-	-	3

Course Description:
Due to wide existing and potential applications, composite technology has been developed very intensively over recent decades. Composite materials whose mechanical properties are controlled by high-strength and high-stiffness continuous fibers embedded in polymeric, metal, or ceramic matrix. Composite materials are ideal for structural applications where high strength to weight and stiffness to weight ratio are required. This course covers study of manufacturing processes, anisotropic elasticity and micro and macro analysis of composite materials.

Course Outcomes:
After completion of this course student will be able to
1. Identify the properties of fiber and matrix materials used in composites.
2. Select an appropriate manufacturing process for composite parts.
3. Analyse fiber composites based on the constituent properties.
4. Design engineering structures with fiber reinforced -composites.
5. Analyse the failure of composite laminate.

Prerequisite: Material Science and Metallurgy, Mechanics of Materials.

Content

Unit No	Description	Hrs
1.	**Introduction to Composites:** Classification composite materials, general characteristics of composite materials, laminae and laminate, applications of composites, material selection process.	06
2.	**Constituents of Composite Materials:** Reinforcement and fillers: glass fibers, carbon fibers, organic fibers, boron fibers, natural fibers, ceramic fibers Matrix: thermoset matrix and thermoplastic matrix, metal matrix materials, ceramic matrix materials.	06
3.	**Manufacturing of Composites:** Bag-molding, compression molding, filament winding, liquid composite molding, metal matrix composite manufacturing, ceramic matrix composite manufacturing, selection of manufacturing method.	06
4.	**Elastic Behavior of Unidirectional Lamina:** **Stress** strain relationship, Anisotropic and Orthotropic materials, Fiber matrix interaction, Failure theories for composite materials. Mechanics of material approach, Elasticity approach. Static mechanical properties, comparison of approaches.	06
5.	**Elastic Behavior of Laminate:**	06

	Classical laminate theory, single layered, configuration, symmetric and antisymmetric laminates, strength of laminates, strength of cross ply and angle ply laminates. Bending of laminated plates. Vibrations of laminated plates.	
6.	**Failure Analysis of Laminates:** Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials.	06

References –

1. K. K. Chawla, Composite Materials: Science and Engineering, Springer, Third Edition.
2. Robert M. Jones, Mechanics of composite materials, Taylor and Francis, second edition 1999.
3. Bryan Harris, Engineering Composite Materials, the Institute of Materials, Landon.
4. Hussain, Farzana, et al., Review article: polymer-matrix nanocomposites, processing, manufacturing, and application: an overview. Journal of composite materials 40.17, 2006:1511-1575.
5. M. Ashby, Material Selection in Mechanical Design, Elsevier, Fourth Edition, 2010.
6. P.K. Mallick, Fiber-Reinforced Composites: Materials, Manufacturing, and Design, CRC Press, Third Edition, 2007.

Program Elective - IV

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Computational Fluid Dynamics** Course Code: **MAE2100**

L	T	P	Credits
3	-	-	3

Course Description:
The Computational Fluid Dynamics is combination of physics, numerical mathematics, and, to some extent, computer sciences employed to simulate fluid flows and heat transfer. Now a days CFD is playing one important role in design, optimization and research in automobile engineering because of its ability to simulate the systems where controlled experiments are difficult or impossible to perform.
This course is base for developing the algorithm for CFD codes which can be used for fluid flow and heat transfer analysis. In this subject more focus is on creating the background for developing FDM and FVM algorithms for steady and unsteady fluid flow and heat transfer.

Course Outcomes:
After completion of this course student will be able to,
1. Describe the physical significance of the governing equations for fluid dynamics and heat transfer.
2. Develop finite difference implicit & explicit algorithms for fluid flow and heat transfer problems.
3. Select appropriate grid generation methods for CFD analysis.
4. Develop finite volume algorithms for Steady and unsteady problems.
5. Select appropriate turbulent model for CFD simulation.

Prerequisite: Engineering Mathematics, Fluid Mechanics and Machinery and Heat transfer.

Content

Unit No	Description	Hrs
1.	**Conservation laws of fluid dynamics and heat transfer.** Models of fluid flow, substantial derivative, divergence of velocity, conservative and non-conservative forms of continuity, momentum and energy equations. Integral and differential analysis, physical boundary conditions. Reynolds transport theorem.	06
2.	**Aspects of discretization** Mathematical behaviour of partial differential equations, Elliptic hyperbolic and parabolic equations. Finite difference approximation, difference equations. Implicit and explicit approximation. Error and stability analysis.	06
3.	**Grid with transformation and CFD techniques** General transformation equation, metrics and Jacobian, stretched, elliptic and adaptive grids. CFD techniques -Lax Wandroff technique, MacMacormac's technique, Relaxation technique, ADI technique.	06
4.	**Finite volume method.**	06

	Finite volume method for Steady state diffusion problems, tridiagonal matrix algorithm. Finite volume method for two-dimensional diffusion problems, Properties of discretization schemes, 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme.	
5.	**Discretization of Convection-Diffusion Equations: A Finite Volume Approach:** Finite volume discretization of convection-diffusion problem: Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme.	06
6.	**Turbulent modeling-** Descriptors and Characteristics of turbulent flow, The effect of turbulent fluctuations on properties of the mean flow, Reynolds-averaged Navier–Stokes equations and classical turbulence models. Large eddy simulation. Direct numerical simulation.	06

References –

3. J. D. Anderson, Computational Fluid Dynamics: The Basics with Applications, McGraw Hill.
4. H. K. Versteeg, W. Malalasekera, an Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education (Indian Edition).
5. K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer_, Second Edition, Narosa Publishing House.
6. K. A. Ho_mann, S. T. Chiang, Computational Fluid Dynamics for Engineers - Volume 1_, Engineering Education System.
7. O. Zikanov, Essential Computational Fluid Dynamics, Wiley India.
8. J. Tu, G. H. Yeoh and C. Liu, Computational Fluid Dynamics: A Practical Approach, Butterworth Heinemann (Indian Edition).
9. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor and Francis (Indian Edition).
10. A. W. Date, Introduction to Computational Fluid Dynamics, Cambridge (Indian Edition).

Program Elective - IV

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Tribology** Course Code: **MAE2110**

L	T	P	Credits
3	-	-	3

Course Description:
Tribology deals with design of fluid containment systems like seals and gasket, Lubrication of surfaces in relative motion to achieve reduced friction and wear. The structure of the bearing and the nature of fluid flow determine the loads that can be supported. Modeling systems as hydrostatic squeeze film and Elasto-hydrodynamic lubrication will be studied as infinite and later finite structures. Gas (air) lubricated and rolling contact type motions with deformation at contact will be studied as special systems.

Course Outcomes:
After completion of this course student will be able to
1. Describe the theories of friction and wear mechanisms.
2. Apply principle of hydrodynamic lubrication for designing bearing.
3. Analyse and optimize the hydrostatic bearing for minimum energy loss.
4. Apply Reynolds equation for designing gas lubrication system.
5. Select appropriate surface treatment for minimum wear and high corrosion resistance.

Prerequisite: Engineering chemistry, Material Science and Metallurgy, Fluid mechanics and Machinery.

Course Content

Unit No	Description	Hrs
1.	**Introduction**: History of tribology, tribology in design, industrial applications of tribology, economic aspects of tribology, tribological aspects for engine components such as bearings, reciprocating components, valve train. Methods of solution of tribological problems.	06
2.	**Friction and wear**: Laws of friction, causes of friction, friction measurement, theories of friction- Adhesion, abrasive, Amonto's theory, Tomlion's and Hardy theory of molecular attraction. Introduction to wear- types of wear and wear mechanisms, factors affecting on wear, measurement of wear. Theories of wear. Methods of controlling wear.	06
3.	**Hydrodynamic Lubrication**: Principle, mechanism of pressure development in oil film, Reynolds equation for hydrodynamic lubrication, hydrodynamic journal bearing, analysis of hydrodynamic journal bearing, Sommerfield number, design consideration in hydrodynamic bearing.	06

4.	**Hydrostatic lubrication**: Principle, advantages, limitations and applications of hydrostatic lubrication, hydrostatic step bearing analysis. Energy loss in hydrostatic bearing. Optimum design of hydrostatic bearing, hydrostatic conical bearing. Rheodynamic lubrication.	06
5.	**Elastohydrodynamic lubrication and Gas lubrication**: Elastohydrodynamic lubrication between two contacting bodies. Hertz's equation for deformation and pressure. Applications of elastohydrodynamic lubrications. Gas lubrication-requirments, merits and demerits of gas lubrication, Reynolds equation for gas lubrication, Air bearings.	06
6.	**Surface engineering**: Introduction, concept and scope of surface engineering, manufacturing of surface layers. Surface engineering for wear and corrosion resistance-diffusion and coating. Properties of coatings. Selection of coating for wear and corrosion resistance.	06

References –

1. H. G. Phakatkar R. R. Ghorpade, Tribology, Nirali Prakashan 2010.
2. S. K. Basu, S. N. Sengupta, B. B. Ahuja, Fundamentals Of Tribology, Phi Learning Pvt. Ltd 1st Edition, 2010.
3. Stachowiak G N, Batchelor A W and Stachowick G B "Experimental methods in Tribology", Tribology Series 44, Editor D Dowson, 2004.
4. Michael M Khonsari, Applied Tribology (Bearing Design and Lubrication), John Wiley & Sons, 2001.
5. Ludema K C, Friction, Wear, Lubrication: A textbook in Tribology, CRC Press, 2010.

Program Elective - IV

Class: **F. Y. M. Tech. Mechanical (Automobile)** Semester: **II**
Course: **Mechatronics** Course Code: **MAE2120**

L	T	P	Credits
3	-	-	3

Course Description:
A car contains many mechatronic systems, such as anti-lock braking systems, traction control, the engine control unit and cruise control, to name a few. A satellite dish position control unit is another example of a mechatronic system. Modern industrial automated processes would not be possible without the discipline of mechatronics, covering areas such as vehicle manufacturing, pharmaceutical industries, and food processing plants. Robotic systems are interesting and complex examples of mechatronic systems that contain many sensors and actuators and that require very fast and sophisticated controllers. This course helps to create interest of students in the field of mechatronics, as this most of the automotive systems are applications of mechatronics.

Course Outcomes:
After completion of this course student will be able to
1. Describe/identify basic elements of mechatronic systems.
2. Describe/identify key elements of sensors and transducers and techniques of interfacing with PLC, Microprocessor and Microcontroller etc.
3. Apply a systematic approach to the design Mechatronics systems.
4. Design mechatronics systems in areas such as manufacturing, automobile systems and robotics.

Prerequisite: Automotive System Design & Theory of Machines and Control Engineering.

Content

Unit No	Description	Hrs
1.	**Introduction to Mechatronics:** Definition of mechatronics, examples of mechatronic systems, components of mechatronic system, the multi-disciplinary process. Basic electrical components (resistors, capacitors, inductors), analyzing and solving simple electrical circuits, basics of Boolean logic, logic gates, designing basic logic circuits.	06
2.	**Actuators & Feedback Devices:** Introduction to actuators, analogy between electrical and magnetic circuits, motor and generator principle, types of actuators-general introduction to motors, brushed DC motors, brushless DC motors, Stepper motor, servo motor, criteria for actuator selection, sizing of actuators.	06
3.	**Microprocessor and Microcontroller** Microcontroller: Comparison between microprocessor and micro controller, organization, architecture, pin diagram, addressing modes, instruction types	06

	and set, Elementary programs, Interfacing input output ports, serial and parallel interfacing requirements, buffers, handshaking, polling and interrupts, Applications-microprocessor/microcontroller based controllers, data acquisition system.	
4.	**Signal Processing & System Dynamics** Operational amplifier circuits, filtering circuits, Analogue & digital signal conversion, System dynamics, first order systems, second order systems.	06
5.	**Programmable Logic Controllers** Advantages & disadvantages of PLC with respect to relay logic, PLC architecture, Input Output modules, PLC interfacing with plant, memory structure of PLC. Basic i/o symbols, fundamentals of ladder diagram, machine control terminology, scan cycle (update – solve ladder – update), physical components Vs. program components, internal relays, fail safe circuits, disagreement circuit, majority circuit, oscillator, holding (sealed or latches) contacts, always ON always OFF contacts, Nesting of ladders.	06
6.	**Mechatronics system Design** User Requirements Specification (URS), Steps in mechatronic system design. Case studies.	06

References –

1. W. Bolton, Mechatronics, Pearson education, 6th Edition, 2015.
2. Mahalik, Mechatronics, TATA McGraw Hill, 2003.
3. Hackworth & Hackworth, Programmable logical controller, Pearson Education, 2004.
4. David Alciatore, Michael B, Histand, Introduction to Mechatronics & Measurement systems, Mc Graw Hill, 4th edition, 2011.
5. Gaokar, Microprocessor 8085, Penram Publication, 6th Edition, 2013.
6. Appu Kuttam, Mechatronics, Oxford publications, 2007.
7. S. Brain Morris, Automated Manufacturing systems, McGraw Hill.
8. Reis Webb, Principles Applications Programmable logical controller, Prentice Hall, 1992.

Class: **S. Y. M. Tech. Mechanical (Automobile)** Semester: **III**
Course: **Industry Internship** Course Code: **MAE3010**

L	T	P	Credits
-	-	-	Audit

Course Description:

There is a need of bridging the gap for theoretical knowledge of the students with the rapidly changing Industrial scenario. For the same, Industry internship of 30 days will provide an opportunity for the students to work closely with the Industries which will help to improve practicability of the students. Further, it is expected to identify problems in the respective Industries during that period which will open up new avenues for research for solving those problems.

Course Outcomes:

After completion of this course student will be able to

1. Acquire sufficient knowledge in the respective Industry.
2. Explain the various departments in the Industry.
3. Identify problems in the process in Industry.
4. Suggest some remedies for the identified problems.

Prerequisite: Nil.

Content

In the industry internship work, the student is expected to get training in the industry, related to subject specialization for duration of 30 days (minimum) for at least 6 hrs per day. Student should write a report on the field training and submit to department for ISE evaluation at the beginning of third semester. Student should include the certificate from the company regarding satisfactory completion of the field training.

Class: **S. Y. M. Tech. Mechanical (Automobile)** Semester: **III**
Course: **MOOC Course** Course Code: **MAE3020**

L	T	P	Credits
-	-	-	3

Student can opt for online certification course and produce certificate.

1. The students who are doing course on MOOC/NPTEL Course /Courses suggested by DPGC should select the course in consultation with supervisor and submit the details to Head of Program.
2. The course should be minimum of 25 hours duration and should have certification facility.
3. Student should complete course and get certificate. The certificate copy should be submitted to head of program with supervisor signature.
4. If student fails to produce this certificate at the time of ESE, he or she will not be eligible to give ESE of Online/certification course.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Identify the real applications and practices of courses studied, at industry level
2. Recognize various modeling, analysis and validation techniques adopted at industries.
3. Demonstrate the issues at design, manufacturing and assembly levels.
4. Summarize and present technical data in report format.

Class: **S. Y. M. Tech. Mechanical (Automobile)** Semester: **III**
Course: **Dissertation Stage-I** Course Code: **MAE3030**

L	T	P	Credits
-	-	8	4

Course Description:

Dissertation Stage I and Synopsis Approval Presentation:

Under the guidance of faculty called as Supervisor, PG student from second year is required to do innovative and research oriented work related to various theory and laboratory courses he/she studied during previous semesters. Dissertation work should not be limited to analytical formulation, experimentation or survey based project. Student can undertake an interdisciplinary type project with the prior permission of DPGC from both departments.

Synopsis:

Student need to carry out exhaustive literature survey with consultation of his/her Supervisor for not less than 25 reputed national international journal and conference papers. Student should make the Synopsis Submission Presentation (SSP) with literature survey report to DPGC and justify about the innovativeness, applicability relevance and significance of the work. At the time of presentation, student shall also prepare Synopsis of the work and submit to department for approval. Student shall submit synopsis of dissertation as per the prescribed format in 02 copies to department.

Course Outcomes:

After successful completion of the course, students will be able to,

1. Explain the contributions of various researchers in the field of design engg after carrying out literature survey from reputed journals
2. Recognize the gap in the research and define a problem statement
3. Explain significance and applicability of problem statement
4. Summarize and present technical data in report format

Class: **S. Y. M. Tech. Mechanical (Automobile)** Semester: **III**
Course: **Dissertation Stage-II** Course Code:**MAE3040**

L	T	P	Credits
-	-	12	6

Course Description:
Stage II evaluation is based on End Semester Examination (ESE) which is based on the work during the semester. It is expected that student shall present preliminary results from his/her work during the semester with report as per prescribed format. DPGC including external examiner as expert will approve the report and progress of student. ISE will be evaluated by DPGC and ESE will be evaluated by DPGC and one external expert. Student will submit a report (soft bound before 1 week of date of presentation) as per prescribed format and present to DPGC for ISE and ESE. If student is not showing satisfactory performance, then he /she will be given grace period of 2 week. After 2 weeks, student will again evaluated with grade penalty.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Outline the work plan for problem statement
2. Identify the proper modeling and analysis tool
3. Reproduce the preliminary results of problem statement
4. Summarize and present technical data in report format

Class: **S. Y. M. Tech. Mechanical (Automobile)**
Course: **Dissertation Stage-III**

Semester: **IV**
Course Code: **MAE4010**

L	T	P	Credits
-	-	12	6

Course Description:

Student is required to make a presentation on the progress of his/her dissertation work in front of supervisor and DPGC. It is expected that up to this stage almost 90% of the dissertation work is completed. Student will make the presentation and seek the suggestions from the supervisor and DPGC. Supervisor and DPGC will ensure that work carried out by the students till this stage is satisfactory and in compliance with synopsis of the dissertation submitted by the student. This is In Semester Evaluation (ISE).

Course Outcomes:

After successful completion of the course, students will be able to,

1. Explain the issues related to method adopted in solving the problem
2. Select proper technique in solving the problem
3. Compare the results with available literature

Class: **S. Y. M. Tech. Mechanical (Automobile)**
Course: **Dissertation Stage-IV**

Semester: **IV**
Course Code: **MAE4020**

L	T	P	Credits
-	-	20	10

Course Description:
This is the final presentation i.e. viva voce of the dissertation. Student will be allowed to make this presentation only if he has submitted duly completed and certified dissertation report. Students will make the presentation in front of supervisor, DPGC and external supervisor. Examiners will check whether the dissertation work is in full compliance with synopsis of dissertation or not. Dissertation will assess on the bases quality of dissertation work, efforts taken by the student, quality of the paper(s) published on the dissertation work etc.

Course Outcomes:
After successful completion of the course, students will be able to,
1. Design new methodology to address the problem
2. Justify the results obtained from new methodology
3. Write technical report and defend work.