ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 7
(Syllabi for Automobile Engineering Programme Courses)
(Revised on Jul 2024)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21AUC201T	Course Name	APPLIED THERMAL ENGINEERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*identify the fundamental concepts of thermodynamic systems and energy transfer*
CLR-2:	*utilize thermodynamic laws and their applications*
CLR-3:	*utilize the concept of pure substance and rankine cycle*
CLR-4:	*enlighten the knowledge in Otto, Diesel, Dual cycle*
CLR-5:	*construct knowledge on air compressors, refrigeration systems and air conditioning systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concept of thermodynamic properties to quantify energy transfer*	*3*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*2*	*-*
CO-2:	*apply thermodynamic laws to analyze various thermodynamic systems, Exergy analysis*	*3*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*2*	*-*
CO-3:	*apply the concept of entropy and availability to thermodynamic systems and to do*	*-*	*2*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*1*
CO-4:	*evaluate the properties of pure substances and analyze vapour power cycles*	*-*	*2*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*1*
CO-5:	*calculate performance of air conditioning system using Psychrometric chart and applications in automotive climate control*	*-*	*-*	*1*	*-*	*-*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*

Unit-1 – Concept of Energy, Systems, Processes, Work and Laws of Thermodynamics ***9 Hour***

Thermodynamic system, control volume, properties, state, process and cycle, thermodynamic equilibrium, Quasi-static process, pure substance, state postulate, concept of temperature, zeroth law of thermodynamics, work and heat interactions, path function and point function, PdV work for various quasi-static processes, tutorials on work and heat transfer. First law of thermodynamics for a closed system, Forms of energy, concept of total energy E, Tutorials on first law of thermodynamics for a closed system, constant volume, constant pressure, process in which PV=C, Tutorials on poly tropic, adiabatic process, Combination of different process, Internal energy and Enthalpy, specific heats, derivation of general energy equation for a control volume, application of SFEE to various steady flow devices, Tutorial on first law applied to various steady flow devices

Unit-2 – Limitations of First Law and Second Law of Thermodynamics ***9 Hour***

Limitations of first law of thermodynamics, cyclic heat engine, energy reservoirs, pump, thermal efficiency and COP, Kelvin – Planck and Clausius statement of second law of thermodynamics, equivalence of the two statements, tutorials on second law of thermodynamics, reversible and irreversible process, causes of irreversibility, Carnot cycle, working of a Carnot engine, thermal efficiency of a Carnot engine, Tutorials on Carnot engines, ReversedCarnot cycle, Carnot's theorem, efficiency of Carnot heat engine, COP of Carnot refrigerator, Carnot heat pump, COP, Tutorials on combined heat engine & refrigerator/heat pump system. Clausius theorem, Concept of entropy, T-s diagram, Clausius inequality, Entropy principle, Application of the concept of Clausius theorem, Tutorials on change in entropy for solids and liquids, Available and unavailable energy, Irreversibility, Tutorials on availability

Unit-3 - Pure Substances ***9 Hour***

Phase change phenomenon of a pure substance, Property diagrams for phase change process, T-V, P-V, P-T diagram, P-v-T surface, Critical point and Triple point, T-s and h-s diagram, Dryness fraction, Use of Steam tables, Mollier chart, Identification of states & determination of properties, Tutorials oncalculation of steam properties, Rankine cycle, Operation of Rankine cycle, Analysis of Rankine cycle, Problems solving on Rankine cycle, Reheat – regeneration in Rankine cycle – Organic Rankine cycle

Unit-4 - Properties of Ideal Gases	***9 Hour***
Equation of state, Vander Waal's equation of state, specific heats and entropy of gas mixtures, Maxwell's relations, T-ds relations, Equations for dH and dU, Clausius – Clapeyron Equation, Joule – Thomson experiment, Joule – Thomson coefficient, Tutorials on Thermodynamic relations, Introduction, air standard cycles –Otto cycle, Diesel cycle, Dual cycle – significance, Pv and Ts diagram, work done, mean effective pressure, brake thermal efficiency	
Unit-5 – Air Compressor	***9 Hour***
Construction and Working of Single acting and double acting air compressors, basics of Intercooler, construction, working of multi – stage air compressor, compressor –Isentropic, adiabatic and polytropic, work done without clearance volume – FAD definition – fundamentals of refrigeration cycle – simple vapor compression refrigeration system, simple vapor absorption refrigeration system – construction and working, desirable properties of an ideal refrigerants. Properties of atmospheric air, psychrometric chart, dry bulb temperature and wet bulb temperature, psychrometric processes- sensible heating and cooling, humidification, dehumidification, cooling and dehumidification heating and humidification, Bypass factor for heating and cooling coils, application of air conditioning systems in automobiles, study of Automotive air conditioning systems, automotive climate control – climate governing factors	

Learning Resources	1. *Mahesh M. Rathore, Thermal Engineering, Tata McGraw HillEducation, 2012* 2. *Yunus. Acengel., Michael A Boles, Thermodynamics – An Engineering Approach, 8th ed., Tata McGraw Hill- Education, 2015* 3. *Nag. P.K, Engineering Thermodynamics, 5th edition, Tata McGraw Hill Education, 2013*	4. *R. Rudramoorthy, Thermal Engineering, 4th ed., Tata McGraw-Hill, 2007* 5. *C.P. Kothandaraman, Fundamentals of Heat and Mass Transfer, 4th ed., New Age International Publishers, 2012*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	-	*15%*
Level 2	*Understand*	*25%*	-	-	*20%*	-	*25%*
Level 3	*Apply*	*30%*	-	-	*25%*	-	*30%*
Level 4	*Analyze*	*30%*	-	-	*25%*	-	*30%*
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Gunabalan, Manager, R&D Turbo Energy,Chennai,*	1. *Dr. Chandramohan, NIT Warangal,*	1. *Mr. S. Logeshwaran, SRMIST*
2. *Mr. Shantha Kumar, Lead Engineer, Royal Enfield,*	2. *Dr. Ganesh, Anna University, Chennai*	2. *Dr. C. Prabhu, SRMIST*

Course Code	21AUC202J	Course Name	AUTOMOTIVE ENGINES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*know about Various components of the engine, materials and its functions*
CLR-2:	*impart knowledge about the combustion process in SI Engine*
CLR-3:	*impart knowledge about the combustion process in CI Engine*
CLR-4:	*provide an insight about the lubrication, cooling system used in IC engines*
CLR-5:	*provide an insight about the turbo, supercharging and scavenging system in IC Engines*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the components of the engine, materials and its functions*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*3*	-
CO-2:	*evaluate the performance of SI Engines*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*3*	-
CO-3:	*evaluate the performance of CI Engines*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*3*	-
CO-4:	*understand the lubrication and cooling system in IC Engines*	*3*	*3*	-	-	-	-	*2*	-	-	-	-	-	*3*	*3*	-
CO-5:	*understand the turbo, supercharging and scavenging system in IC Engines*	*3*	*3*	-	-	-	-	*2*	-	-	-	-	-	*3*	*3*	-

Unit-1 – Intake and Exhaust Systems Components ***12 Hour***

Constructional details of engine components –Functions and materials- Valve timing diagram for SI and CI engine- Port timing diagram for SI and CI engine- Firing order and its significance –Tutorial 1: Comparison of Valve Timing Diagrams for SI and CI engine –Intake system components – Discharge coefficient, Pressure drop Air filter, intake manifold, Connecting Pipe Exhaust system components Exhaust manifold and exhaust pipe Spark arresters Exhaust mufflers, Types and operation-Exhaust after treatment systems.

Practice:

1. Dismantling study and assembling of IC engines – Measurement of Bore, Stroke, Ovality and Taper, 2.Valve Timing Diagram for Four Stroke Engine and port Timing Diagram for Two Stroke Engine

Unit-2 – Combustion in SI Engine ***12 Hour***

Stages of combustion-Nature of charge –Flame propagation –Flame velocity and area of flame front- Rate of pressure rise – Cycle to cycle variation- Abnormal combustion – Theories of detonation-Comparison of SI and CI engine combustion process- Introduction to Combustion chambers- Effect of engine operating variables on combustion –combustion chambers types-factors controlling combustion chamber design-Modelling SI engine combustion. -Overview

Practice:

1. Study of fuel supply system, 2. Performance test on Petrol engine

Unit-3 – Combustion in CI Engine ***12 Hour***

Stages of combustion-Nature of charge –Mixture formation in CI engines – Importance of air motion Swirl, squish and turbulence Swirl ratio. Fuel air mixing – Factors affecting delay period- Knocking in CI engines – methods of controlling diesel knock- CI engine combustion chamber: Types – Design objectives – Factors influencing Combustion chamber design- Modelling CI engine combustion. -Overview-Advanced combustion concepts: Homogeneous charged compression ignition- Premixed charged compression ignition-Reactivity charged compression ignition.

Practice:

1 .Performance test on diesel engine, 2. Test for optimum coolant flow rate in IC engines

Unit-4 – Lubrication and Cooling Systems	***12 Hour***
Need for cooling system- Types of cooling system –Air cooled system-Liquid cooled system –Thermosyphon system- Forced circulation system- pressure cooling system –Properties of coolant- additives for coolants Need for lubrication system- Lubrication methods: Mist lubrication system-wet sump any dry sump lubrication –Properties of lubricants-consumption of oil.	
Practice:	
Determination of viscosity of the lubricating oil. 2. Determination of flash and fire point of the fuel.	
Unit-5 – Turbo Charging, Supercharging and Scavenging	***12 Hour***
Objectives of Super charging-Methods to boost the engine power –Turbo charging methods-Thermodynamics of Turbocharging –Turbo lag-Windage losses Engine exhaust manifold arrangements-Classification of scavenging systems Mixture control through Reed valve Induction – Charging Processes in two-stroke cycle engine – Terminologies Shankey diagram – perfect displacement, perfect mixing.	
Practice:	
1.Energy Balance test on an Automotive Diesel Engine, 2 Morse test on petrol engines	

Learning Resources	1. *Ganesan V, "Internal combustion engines", 4th edition, TataMcGraw Hill Education, 2012.* 2. *Rajput R. K, "A textbook of Internal Combustion Engines", 2nd edition, Laxmi Publications (P) Ltd, 2007.* 3. *Internal Combustion Engine Fundamentals, 2nd Edition. John B. Heywood. ISBN: 9781260116106. Publication Date & Copyright: 2018.McGraw-Hill Education*	4. *Ramalingam K. K, "Internal Combustion Engines", Second Edition, Scitech Publications,2009* 5. *Edward F, Obert, "Internal Combustion Engines and Air Pollution", IntextEducation Publishers, 1980*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*25%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Jayaraman.R,BLG Logistics,jayaraman.r@blgparekh.com*	1. *Dr.M.Parthasarathy, Vel Tech,nparthasarathy@veltech.edu.in*	1. *Dr. T.Prakash, SRMIST*
2. *Mr. Shanmuga Sundaram, RNTBCI, sankaran@rntbci.com*	2. *Dr.P.Nanthakumar, Amrita school of Engineering, p_nanthakumar@cb.amrita.edu*	2. *Dr. C.Prabhu, SRMIST*

Course Code	21AUC203J	Course Name	MANUFACTURING TECHNOLOGY FOR AUTOMOTIVE ENGINEERS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*acquire knowledge of various conventional manufacturing processes*
CLR-2:	*utilize the work and tool holding devices*
CLR-3:	*identify the various surface finishing process and coating techniques*
CLR-4:	*identify the fundamental concepts of CNC machining*
CLR-5:	*compare various advanced manufacturing techniques for suitable applications*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply different welding and casting techniques for suitable applications*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*compare the advanced metal forming process and current role in industries*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*3*	*1*	-
CO-3:	*produce prismatic components and Gears*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*apply the knowledge of CNC machining in various Automotive component manufacturing*	*2*	-	-	-	*3*	-	*2*	-	-	-	-	-	*2*	-	-
CO-5:	*select viable manufacturing process of complex parts alternative to conventional manufacturing*	-	-	*1*	*3*	-	-	*2*	-	-	-	-	-	-	-	*1*

Unit-1 - Conventional Manufacturing - Overview **12 Hour**

Introduction to Welding- classifications – Types – Working principles of ARC, MIG, TIG, SPOT, Laser welding – Welding defects – Welding Applicationin Automobile. Introduction to casting – Pattern materials & types – Shell, investment & pressure die casting – casting defects – casting application in Automobile. Introduction to Forging – types & defects – Rolling process – types & defects – Extrusion process & defects – tube drawing - sheet metal operations – Bending – stretch forming – Deep drawing – Ironing – Hydroforming

Unit-2 - Machining and Gear Manufacturing Process **12 Hour**

Introduction to Machining – theory of metal cutting – Mechanics of chip formation & types of chips – cutting tool materials – Tool life calculation – Tool wear – Tool signature for single point cutting tool – Lathe machine - Types of lathe – cutting fluids & Machinability – Material removal rate – Operating parameter – cutting speed, feed & depth of cut. Introduction to Milling machine – types – milling cutters & Indexing process – overview of surface machining, drilling operation – Gear forming process – Extrusion & stamping – Gear Hobbing process– types – Gear shaping & types - Powder metallurgy technique – sintering – properties of metal powders – particle size and blending – compaction – applications in automobile

Unit-3 - Surface Finishing Treatments **12 Hour**

Introduction to Finishing operations – Grinding machine - surface & cylindrical – external, internal & Centre less – Automotive Application of Lapping – Honing – Buffing – Deburring – shot blasting – shot peening. Superfinishing process – cylindrical & centerless micro honing – Application – Electrochemical polishing – protective & decorative coating techniques – Applications.

Unit-4 - CNC Machine Tools **12 Hour**

Evolution of CNC Technology – principles – features – advantages – CNC & DNC concept. Classification of CNC Machines – Turning centre, machining centre, EDM, Types of control systems – CNC controllers – characteristics – interpolators – computer-aided inspection. CNC Machine building – structural details – configuration & design – guide ways – Friction, Anti friction – spindle drives – DC shunt motor - Feed drives – stepper motor, servo principle, DC & AC servo motors – open loop & closed loop control – Axis measuring system – Gratings – encoders – Laser interferometer.

Unit-5 - Additive Manufacturing Techniques	***12 Hour***
Introduction to Additive Manufacturing – Importance of rapid prototyping – classification – Advantages – Stereo Lithography – Multi jet modelling – Powder based techniques – selective Laser sintering – 3D Printing – its working & applications – Fused deposition modelling – Laser powder bed fusion process.	

Learning Resources		
	1. *Seropkalpakjian, Manufacturing Engineering and Technology,7th ed., Pearson Education, 2013.* 2. *P.N. Rao, Manufacturing technology – Machining and MachineTools, Vol. 2, 3rd ed., Tata Mc Graw Hill, 2017* 3. *P.N. Rao, Manufacturing technology – Foundry forming and welding, Vol. 1, 4th ed. Tata Mc Graw Hill, 2013.*	4. *Mikel P Groover, Fundamentals of Modern Manufacturing, 4th ed., JohnWiley and Sons, 2009.* 5. *Sharma P C, A Text Book of Production technology – manufacturingProcesses, S Chand & Company, New Delhi.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 3	*Apply*	*50%*	*-*	*-*	*50%*	*50%*	*-*
Level 4	*Analyze*	*-*	*-*	*-*	*-*	*-*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Ajeet Babu ARAI,ajeetbabu.fid@araiindia.com*	1. *Dr. B. Mohan Anna University bmohan@annauniv.edu*	1. *Mr.S. Palanisamy, SRMIST*
2. *Mr.Dalpat Singh M & M, singh.dalpat@mahindra.com*	2. *Dr.R.Elansezhian, Pondicherry Engineering College,elansezhianr@gmail.com*	2. *Dr. J. Chandradass, SRMIST*

Course Code	21AUC301T	Course Name	CAD ANALYSIS FOR AUTOMOTIVE ENGINEERS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe the various design concepts and modelling techniques*
CLR-2:	*introduce the latest developments in CAD Packages*
CLR-3:	*understand the basic knowledge of automotive components respective to design*
CLR-4:	*provides the knowledge on forces of connecting rod*
CLR-5:	*familiarize the design procedure of engine components*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*create the design models by various technique*	*3*	*-*	*3*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*2*	*-*
CO-2:	*develop the model using various features*	*3*	*2*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-3:	*explain the procedure involved in design*	*3*	*-*	*2*	*1*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-4:	*familiarize with various design standards*	*3*	*3*	*2*	*-*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-5:	*design various automotive components to suit industrial needs*	*3*	*-*	*-*	*2*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*1*	*-*

Unit-1 - Introduction to CAD — ***9 Hour***

Introduction to CAD, Product life cycle management, Design models – Pahl and Beitz model, Shigley model and Ohsuga model, Geometric modelling,Constructive solid geometry, Boundary representation, Introduction to Coordinate system, Model coordinate system, Transformations in 2D and 3D, Concatenated and Inverse transformation, Visibility techniques – Minimax test, Containment test, Hidden line removal – priority algorithm

Unit-2 - Modelling and Software Packages — ***9 Hour***

Introduction to Software Packages, Salient features and technical comparison, Modules and tools, Open-source tools (FreeCAD, LibreCAD), Need for dataexchange standards and types, Structure of STEP file system: Advantages and Disadvantages, Structure of IGES file system: Advantages and Disadvantages, outline of feature technology, Classification of features, Design by features, Applying features t o various automotive components, Advantages and limitations of feature-based modelling. Introduction to GD & T, Need of GD&T, Geometrical tolerance, Dimensional tolerance.

Unit-3 - Design of Cylinder and Piston — ***9 Hour***

Introduction to Cylinder And Piston, Principal Parts of an IC Engine, Cylinder and Cylinder Liner, Design of Bore, Length, Thickness of cylinder head, studs size of the cylinder head, Material for piston, Design of critical parameters of piston: Piston Rings, Piston Skirt, Piston pin. Modelling of cylinder and piston using CADsoftware.

Unit-4 - Design of Connecting Rod — ***9 Hour***

Introduction to Connecting Rod, Material selection for connecting rod, Forces Acting on the connecting rod, Dimensions of cross Section of the connecting rod, Dimensions of the crank pin at the big end, Dimensions of the piston pin at the small end, Size of bolts for securing the big end cap, Thickness of the big end cap.Modelling of Connecting Rod using CAD software.

Unit-5 - Design of Crankshaft — ***9 Hour***

Introduction to Crankshaft, Introduction about crank shaft and its function in an I.C Engine, Materials selection for crankshaft, Bearing pressures andstresses in crankshaft, Design Procedure for Crankshaft, Design of Centre Crankshaft When the crank is at dead centre, Design of Centre Crankshaft When the crank is at angle of maximum twisting moment, Design of Overhung Crankshaft When the crank is at dead centre, Design of Overhung Crankshaft When the crank is at an angle of maximum twisting Moment, Modelling of crankshaft using CAD software

Learning Resources	1. *Ibrahim Zeid, "CAD / CAM - Theory and Practice"., Tata Mcgraw-Hill, New Delhi, 2009* 2. *Radhakrishnan. P "CAD / CAM / CIM" New age international,2018* 3. *Mikell P. Groover, "CAD / CAM"., Prentice Hall of India PrivateLimited, New Delhi, 2003*	4. *Khurmi, "A text book of Machine Design", S Chand publication, 2016.* 5. *Bhandari V, "Design of Machine Elements", Tata McGraw-Hill Education,2010.* 6. *Shigley J, "Mechanical Engineering Design", Tenth Edition, Mc Graw Hill,2014.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*50%*	-	*50%*	-	*50%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.B.Prabhakaran, Continental prabhakaran.balaraman@continental-corporation.com*	1. *Dr.P.D.Jeyakumar, Crescent Institute of Science andTechnology, pdjeyakumar@gmail.com*	1. *Dr.J. Chandradass, SRMIST*
2. *Mr.S.Vengatesan, RNTBCI, vengatesan.subramanian@rntbci.com*	2. *Dr.R.PrabhuSekar, Motilal Nehru National Institute of Technology, rprabhusekar@mnnit.ac.in*	2. *Mr.G.Naresh, SRMIST*

Course Code	21AUC301L	Course Name	DESIGN OF AUTOMOTIVE SYSTEMS LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	Describe the need of computer aided design
CLR-2:	Demonstrate the various 2D sketching tools
CLR-3:	Demonstrate the various 3D modelling tools

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	Understand the need of computer aided design	2	-	2	2		-	-	-	-	-	-	-	2	-	2
CO-2:	Create 2D drawings using sketching tools	3	3	3	2	3	-	-	-	-	-	-	-	3	3	3
CO-3:	Develop 3D models using different features of solid modelling	3	3	3	3	3	-	-	-	-	-	-	-	3	3	3

Practice -	30 Hour
Practice: 1 Introduction to Computer Aided Design and 2D Sketch tools	
Practice: 2 Modelling of Piston, connecting rod , crank shaft and, cam shaft	
Practice: 3 Modelling of Gearbox assembly	
Practice: 4 Modelling of Slip joint, Universal joint and Propeller shaft	
Practice: 5 Modelling of Differential Assembly	
Practice: 6 Modelling of Steering Gear box	
Practice: 7 Modelling of Clutches	
Practice: 8 Modelling of Front axle assembly	
Practice: 9 Modelling of braking system	
Practice: 10 Modelling of Wheel assembly	

Learning Resources	
1. Radhakrishnan. P "CAD / CAM / CIM" New age international, 2018 2. Introducing solidworks "Dassault systems", 2014 3. Matt Loambard, "Mastering Solidworks", 201	4. Nitin.S. Gokhale, "Practical finite element analysis", Hyperworks, 2020 5. Huei-Huang Lee, "Finite Element Simulations with ANSYS Workbench 2020", SDCPublications, 2020

Learning Assessment									
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	20%	-	20%	-	20%	-	-
Level 2	Understand	-	30%	-	30%	-	30%	-	-
Level 3	Apply	-	30%	-	30%	-	30%	-	-
Level 4	Analyze	-	30%	-	30%	-	30%	-	-
Level 5	Evaluate	-	-	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.P. Nirmalkumar, Hubbell India, nirmal06kumar@gmail.com	1. Dr.P.D.Jeyakumar, Crescent Institute of Science and Technology, pdjeyakumar@gmail.com	1. Mr. P. Baskara Sethupathi, SRMIST,
2. Mr.SuhasKangde,Mahindra &Mahindra, kangde.suhas@mahindra.com	2. Dr.R.PrabhuSekar, Motilal Nehru National Institute of Technology, Prayagraj, rprabhusekar@mnnit.ac.in	2. Dr. J. Chandradass, SRMIST

Course Code	21AUC302J	Course Name	VEHICULAR STRUCTURES AND DRIVELINE SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*familiarize the structure of Vehicle frames, Front and Rear axles*
CLR-2:	*acquire knowledge about various types of automotive driveline systems*
CLR-3:	*explore the various components and functions of steering and suspension systems*
CLR-4:	*understand the different types of automotive transmission systems*
CLR-5:	*impart the knowledge of braking system, Wheels and tyres*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*demonstrate the basic structure of an automobile and various types of axles*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*identify the various types of automotive driveline systems*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*classify the different types of steering and suspension systems*	*3*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	-
CO-4:	*classify the different types of transmission systems*	*3*	-	*2*	-		-	-	-	-	-	-	-	-	-	-
CO-5:	*identify the various types of braking systems, wheels and tyres*	*3*	-	-	*1*		-	-	-	-	-	-	-	-	-	-

Unit-1 - Frames, Front and Rear Axles ***12 Hour***

Different types of chassis layout- FF, FR,RR and 4WD - Types of vehicle body and Classifications - Frames- construction, Materials, Loads Acting on frames – Types of vehicle frames-Ladder frame, Tubular frame - Integral frame, X-frame, Roll-cage frames - Common vehicle platform- Need, merits and demeritsCase study - Volkswagen PQ platform, Nissan B platform, Front axle – Live axles, Dead axles, Drop axles, Push and tag axles – Rear axles - Semi, full andthree quarter floating – Types of rear axle housing - Split Banjo and Salisbury type – Multi link rear axles practice 1: Study and measurement of various types of vehicle frame, body and driver seat. 2: Study of different types of front and rear axles and final drives. Calculation of final drive ratio.

Unit-2 - Transmission System ***12 Hour***

Types of clutches, construction and working of single plate - Multi plate and centrifugal clutch - Torque capacity of clutch – Numerical Analysis - Simple problems Fluid coupling – Construction and principle of operation - Torque converters – Construction and principle of operation - Hydro kinetic drives - Multistage torque converters – Polyphase torque converters. Types of gear boxes - Working of sliding And constant mesh gear boxes - Construction and working of synchromesh gear box and principle of synchronizers - Planetary gear box - construction and working - Numerical in Gear box - Automatic transmission - Chevrolet turbo glide Construction and working - Chevrolet Power glide - Construction and working - Hydraulic clutch actuation for Automatic transmission. Practice 3: Dismantling, study and assembling of a given clutch and calculate the maximum torque carrying capacity. 4: Dismantling study and assembling of a given gear box and calculate the gear ratio

Unit-3 - Drive Line and Final Drives ***12 Hour***

Effect of driving thrust and torque reactions - Hotchkiss and torque tube drive – Front wheel drive - Propeller shaft –Construction, Critical Speed - Universal joint, Slip joint , Constant velocity joint and Tripod joint. Different types of final drive - Worm and worm wheel, Straight bevel gear, Spiral bevel gear and hypoid gear final drives - Double reduction final drive – Twin speed final drive - Differential- Principle and constructional details - Differential lock – Limited slip differential. Practice 5: Dismantling, study and assembling of propeller shaft, Universal joint, Slip joint, Constant velocity joint and Tripod joint 6: Dismantling, study and assembling of Final drive assembly and calculation of final gear ratio.

Unit-4 - Steering and Suspension Systems	***12 Hour***
Front wheel geometry - Caster, Camber, Toe in and toe out, SAI - Steering systems - True rolling motion of wheels and Numerical Analysis – Simple problems - Ackermann and Davis steering Mechanism - Constructional details of steering linkages for rigid and independent front axles. Steering gear box - Re-circulating ball type, Rack and pinion type, Worm and Nut type - Power assisted steering - Hydraulic and EPS – Four wheel steering Need for suspension system. Types of suspension - Non independent and independent suspension - McPherson and Wishbone suspension - Types of suspension springs - Leaf spring, Coil spring, Torsion bar, and Rubber springs – Shock absorbers – Pneumatic suspension - Rear axle suspension system - Independent, Trailing Arm - De-dion suspension and torsion beam - Anti-roll bar, Pan hard rod and Radius rod. Practice 7: Dismantling, study and assembling of different automobile steering systems Practice 8: Dismantling, study and of automobile suspension system.	
Unit-5 - Brakes, Wheels and Tyres	***12 Hour***
Theory of braking - Stopping distance - Braking efficiency, Numerical analysis - Drum brakes - Single cam, Double cam - Leading and Trailing shoe types - Disc brakes - Fixed, floating and radial mounted calipers - Ventilated discs, cross drilled discs, slotted discs - Mechanical and hydraulic brake actuation - Pneumatic braking system - Vacuum assisted hydraulic brakes - Air assisted hydraulic brakes - Need for ABS, ESP, EBD and Regenerative braking systems. Types of Wheels - Dimensions and Constructional details of wheels - Types - Construction - Cross ply, Radial ply - Tube and tubeless tyres - Tyre designation – Tread patterns Practice 9: Dismantling, assembling and bleeding of a hydraulic braking system. Practice 10: Study of different types of wheels and tyres	

Learning Resources		
	1. *Kirpal Singh, "Automobile Engineering - Vol I", StandardPublishers Distributors, 1999.* 2. *Crouse W.H, Anglin D.L, "Automotive Transmission and PowerTrain construction", McGraw Hill, 1976*	3. *Heldt P.M, "Torque converters", Chilton Book Co., 1992.* 4. *Newton Steeds &Garrot, "Motor Vehicles", SAE International andButterworth Heinemann, 2001.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*CLA-2 - practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*30%*	-	-	*30%*	*30%*	-
Level 3	*Apply*	*50%*	-	-	*50%*	*50%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. R. Siva GM GMMCO – Caterpiller rsiva@gmmcoindia.com*	1. *Dr. PD Jayakumar Prof & Head, Dept of Auto, Cresent pdjeyakumar@cresent.education*	1. *Dr.K.Kamalakkannan SRMIST*
2. *Dr. Vijayabalan, Professor & Head Department of Mechanical Engineering HITS vijayabalan@hindustanuniv.ac.in*	2. *Mr .S. Kiran, SRMIST kirans@srmist.edu.in*	

Course Code	21AUC303J	Course Name	AUTOMOTIVE ELECTRICAL AND ELECTRONIC SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*acquire knowledge about the application of electrical and electronics in automotive systems*
CLR-2:	*understanding the working of charging and lighting accessories in automobile*
CLR-3:	*acquire the fundamental electronics applied vehicle motion control system*
CLR-4:	*familiarize the usage of Sensors and actuators in Automobile*
CLR-5:	*know about various electrical equipment diagnostics and testing methods*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the need, requirement and function of basic vehicle batteries and its types*	*3*	*3*	*1*	*1*	*1*	*-*	*-*	*-*	*1*	*1*	*-*	*1*	*3*	*3*	*1*
CO-2:	*describe the charging, lighting and auxiliary electrical system for electrical vehicles*	*3*	*3*	*1*	*1*	*2*	*-*	*-*	*-*	*1*	*1*	*-*	*1*	*3*	*3*	*1*
CO-3:	*acquire and analyze the various fuel ignition and fuel injection system procedure*	*3*	*3*	*1*	*1*	*2*	*-*	*-*	*-*	*1*	*1*	*-*	*1*	*3*	*3*	*1*
CO-4:	*apply knowledge of vehicle dynamics to improve performance*	*3*	*3*	*1*	*1*	*2*	*-*	*-*	*-*	*1*	*1*	*-*	*1*	*3*	*3*	*1*
CO-5:	*analyze the protection system applied to electrical vehicles*	*3*	*3*	*1*	*1*	*2*	*-*	*-*	*-*	*1*	*1*	*-*	*1*	*3*	*3*	*1*

Unit-1 - System Architecture	***12 Hour***
Automotive Electrical and Electronics architecture – Components, connections, and power distribution, Vehicle Batteries- Fundamentals and types, Lead acid battery – Principle, Construction, Rating, Charging and Discharging mechanism, Peukert Criteria. Testing and Fault Diagnosis of Batteries, Starting System – Requirements and Functionalities, Starter motor Construction and Working principle, Starter Drive Mechanism – Introduction and types, Advancements in Battery Technologies. Practice 1: Battery Testing –Hydrometer, Load test, Individual Cell voltage test 2: Starter Motor –Continuity test, Insulation Test, Load test.	
Unit-2 - Electrical Accessories	***12 Hour***
Charging system - Introduction, Alternator – Construction and Working principle, Charging Circuits, Rectification, Voltage Regulator – Principle, construction, working and types, Lighting Circuits – Fundamentals and types, Lighting System regulations, Case Studies in Modern lighting system, Auxiliary Electrical system -Wiper system, Signaling and Warning system, Introduction to D.C charging system. Practice 3: Battery Testing –Hydrometer, Load test, Individual Cell voltage test4: Starter Motor –Continuity test, Insulation Test, Load test	
Unit-3 – Electronic Fuel Injection and Ignition System	***12 Hour***
Introduction – Engine management system, SI Engine Fuel Injector, Single point Fuel Injections, Multi Point Fuel Injections, Merits of MPFI, Testing of Fuel Injectors, programmed ignition system, Distributor less Ignition System, Waste spark analysis, Digital Engine Control Modes, EGR Control variable valve timing, Ignition Controlling – Introduction Closed loop ignition timing, Spark Advance Correction Scheme, Practice 5: Study of Lab view Programming6: ADC interfacing for IR Sensor.	
Unit-4 - ECU for Vehicle Control	***12 Hour***
Introduction – Vehicle motion control, Cruise Control System, Adaptive Cruise Control System – Construction, - Working, Throttle Actuator Stepper Motor Based Control, Antilock Braking Mechanism – Construction, Antilock Braking Mechanism – Working, Tire Slip Controller, Merits of ABS, Electronic Suspension System- Construction, Working Variable Damping, Variable Spring rate, Merits of Electronic suspension system, Electric Power Assisted Steering Mechanism- Construction Working, Four Wheel Steering, Steer-by-Wire, Lab: Review class.Practice 7: PWM Signal generation 8: H-Bridge Motor speed and position Control.	

Unit-5 - Brakes, Wheels and Tyres	***12 Hour***
Introduction – Telematics, GPS Navigation, GPS Structure, Dead Reckoning – Construction, Dead Reckoning – Working, Inertial Navigation System – Construction, Working, In vehicle infotainment systems, ADAS – Introduction, features, Electronic Control System Diagnostics, OBDII – Objective, Comparison of OBD I and OBD II, Diagnostics Fault Codes, Introduction to Model-based Sensor Failure Detection, Model-based Sensor Failure Detection working, Case Study on MAF Sensor calibration, Case Study on MAF Sensor calibration. Practice 9: UART communication for parking sensor 10: Fault Diagnosis using OBD handheld Devices.	

Learning Resources	1. *Tom Denton "Automobile Electrical and Electronic Systems" 3rdedition, Elsiever Butterworth-Heinemann 2004.* 2. *William.B.Ribbens, "Understanding Automotive Electronics" 7thedition Butterworth-Heinemann publications, 2012.*	3. *Ed Doering "NI MYRIO Project Essential Guide" 2013, National Technology and Science Press* 4. *Allan.W.M.Bonnick "Automotive Computer Controlled System2001,Butterworth- Heinemann* 5. *Robert Bosch Gmbh "Bosch Automotive Electric and Electronics" 5th edition Springer- 2007.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*CLA-2 - practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Jegan Amirthalingam, Associate Director, Skill- lync*	1. *Mr. Sam Jebakumar, SRMIST, jebakumj@srmist.edu.in*	1. *Dr.C.Carunaiselvane, SRMIST*
		2. *Dr.T.Praveenkumar, SRMIST*

Course Code	21AUC304J	Course Name	FINITE ELEMENT ANALYSIS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*predict how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects*
CLR-2:	*model any physical system in to a finite element model and solve for its field variables*
CLR-3:	*solve real world complex problems which cannot be solved by analytical methods*
CLR-4:	*practice few commercial standard packages in solving complex problems*
CLR-5:	*understand the basics of multi-body systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply finite element technique to Engineering problems*	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*improve their ability in solving differential equations for real world problems*	3	3	-	2	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*equip themselves familiar with multi-domain phenomenon like thermo-structural problems*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*familiarize themselves with the applications of finite element method & FEA packages*	3	3	-	2	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*solve kinematic and dynamic problems of multibody systems*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Introduction to FEA ***15 Hour***

Comparison Of FEA With Exact Solutions - Methods of engineering analysis - Numerical methods - Types of finite elements - Displacement or shape function Material behavior - Stiffness matrix - Steps involved in FEA –preprocessing and solution - Post processing - 2D and 3D stress element - Strain-displacement relationships - Discretization methods - Discretization process - Rayleigh ritz method - Galerkin method - Advantages and disadvantages of FEA - Applications of FEA

Practice*:*

1. Introduction to ANSYS 2. Cantilever Beam With Point Load at Free End

Unit-2 - One Dimensional Problems ***15 Hour***

Elements and node numbering - Global and local co-ordinates - Natural co-ordinates - Polynomial functions - Displacement function for 1D bar element - General stiffness matrix derivation - Stiffness matrix for 1D bar element - Assembly of stiffness matrix - Force vector - Spring element - Stiffness matrix for spring element - Boundary conditions - Imposing boundary conditions to bar element - Beam element - Stiffness matrix derivation of beam element - Truss element - Stiffness matrix for truss element

Practice*:*

3. Distributed Loading of a 1D Cantilever Beam 4. Application of Distributed Loads

Unit-3 - Two Dimensional Problems ***15 Hour***

Plane stress formulation - CST element - Shape function derivation for CST element - Strain displacement matrix for CST element - Stress strain matrix for CST element - Stiffness matrix derivation for CST element - Temperature effects - LST element - QST element - Axi –symmetric formulation – Iso-parametric formulation - Iso, sub. Super parametric element formulation - Four noded quadrilateral element - 1D heat conduction problems - Derivation of stiffness matrix

Practice*:*

5. Buckling Failure 6. Stress Analysis of Axi-Symmetry Structure.

Unit-4 - Multi-Domain Problems	***15 Hour***
Vibration analysis introduction - Modal analysis of a structure - fluid flow problems - Heat transfer problems - Thermo structural analysis - Introduction to biomedical and MEMS applications – ***Practice.*** *7 Analysis of 2D Truss 8. Thermal Analysis..*	
Unit-5 - Applications of FEA	***15 Hour***
Roll cage analysis - Rotor thermal analysis - Hub analysis - Knuckle analysis - Brake pedal analysis Bump analysis ***Practice:*** *9.Modal Analysis of A Roll cage 10.Crash Analysis of the Roll cage.*	

Learning Resources	1. *David V. Hutton, "Fundamentals of Finite Element Analysis",Tata McGraw Hill Publishing Company Ltd., New Delhi, 2005* 2. *Ahmed A Shabana., "Computational Dynamics ", Wiley &Sons. thirdedition 2017*	3. *Bhavikatti S.S., "Finite Element Analysis", New Age InternationalPublishers, New Delhi, 2008.* 4. *ErdoganMadenci, Ibrahim Guven, "the finite element method and applications in engineering using ansys", Springer (India) Private Limited, NewDelhi, 2011.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination(40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*LearningCLA-2 - Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. K Suresh HAL Sureshhal82@gmail.com*	1. *Dr. R. Jagadeeshwaran, BIT, profresearch@bitsathy.ac.in*	1. *Dr. J. Chandradass,, SRMIST*
2. *Mr. V. Raja Raman, Altair rajarav@asiapac.altair.com*	2. *Dr. Vijayabalan, Professor & Head Department of Mechanical Engineering HITS vijayabalan@hindustanuniv.ac.in*	2. *Mr. P. Baskara Sethupathi, SRMIST*

Course Code	21AUC401J	Course Name	VEHICLE DYNAMICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*learn the basic of overall components related to Vehicle Dynamics – Steering, Suspension, Brakes and Tyres, K & C and Wheel alignment*
CLR-2:	*enable students to understand the role of tyre characteristics and its mechanics for vehicle dynamics.*
CLR-3:	*enable the students to understand vehicle performance, handling and ride aspects and the issues involved in it such as braking, traction, road holding, vehicle control and stability*
CLR-4:	*prepare the students to understand Human response and ride comfort criteria.*
CLR-5:	*demonstrate how to address futuristic vehicle's dynamics requirements (ADAS), Homologation and challenges.*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*Understand different types of Steering, Suspension, Brakes, tires and their significance with respect to application.*	*3*	*3*	*3*	*3*	*3*	*2*	*2*	*1*	*2*	*1*	*2*	*1*	*3*	*3*	*2*
CO-2:	*Predict the necessary forces and moments during tyre/road interaction and basic tyre nomenclature.*	*3*	*3*	*3*	*3*	*3*	*2*	*2*	*1*	*2*	*1*	*2*	*1*	*3*	*3*	*2*
CO-3:	*Compute maximum traction, optimum braking force distribution and stability of the vehicles and their control strategies.*	*3*	*3*	*3*	*3*	*3*	*2*	*2*	*1*	*2*	*1*	*2*	*1*	*3*	*3*	*2*
CO-4:	*Demonstrate the application of fundamental governing equations for longitudinal, lateral and vertical dynamics and able to use state space approach.*	*3*	*3*	*3*	*3*	*3*	*2*	*2*	*1*	*2*	*1*	*2*	*1*	*3*	*3*	*2*
CO-5:	*Simulate the dynamic performance of vehicles*	*3*	*3*	*3*	*3*	*3*	*2*	*2*	*1*	*2*	*1*	*2*	*1*	*3*	*3*	*2*

Unit-1 - Fundamentals of Vehicle Dynamics and Tire Mechanics — ***12 Hour***

Introduction to Automotive Chassis – Basic of Steering system, types of steering, selection based on suspension & FAL, Ackermann Geometry, Wheel Alignment – Toe IN/Out, Caster, Camber and its impact in Tire performance. King Pin Inclination (KPI),King Pin Offset (KPO), Scrub radius, Suspension types – HCV, selection of suspension system based on road conditions/axle loads/ride comfort, Brakes – Disc & Drum brakes, Wheel rim types (Steel & Al Alloy), Wheel Rim Profile (B, J, JJ etc). Practical: Wheel alignment.

Tyre & Vehicle axes systems - Mechanical Properties of Rubber- Tyre types and construction -Tyre forces and moments - Slip, Grip and Rolling Resistance, Contact Patch and Contact Pressure Distribution -Cornering properties of tyres (Practical – Tyre cut section study) TPMS - Tire Brush Model Tyre Models – Magic Formula, Lateral Force Generation, Ply Steer and Conicity, Classification of Tyre Models and Combined Slip, Tire noise, NVH – Random Processes.

Practice 1: Introduction to modelling of dynamic systems using Simulink / Simscape / Modelica tools.

Practice 2: Simulation and analysis of single, two degree of freedom systems using Simulink / Simscape / Modelica. Case study to be offered by Volvo – Estimation of rolling resistance for a given tire fitted in a truck.

Co Teaching Area / Content by Volvo - Complete Vehicle Model (CVM) approach for truck design followed in Volvo Group.

Unit-2 - Longitudinal Dynamics and Vertical Dynamics — ***12 Hour***

Vehicle forces - Longitudinal forces and resistances - Rolling resistance, Aerodynamic drag force, Traction force, Deceleration and speed control, brake drag, Road gradient forces. Performance characteristics - Maximum tractive effort - Power plant and Transmission characteristics - Braking performance- Brake force distribution, brake efficiency, braking distance, Anti lock brake system and Traction control system.

Homologation for braking system IS 11852-2013. *Vehicle ride characteristics Sprung & Unsprung mass, Stiffness, damping ratio, Human response to vibration - Vehicle ride models -Quarter car model - pitch and bounce-bounce and roll model -Suspension performance for ride-vibration isolation - suspension travel - Road holding - Active and Semi-active suspensions, Suspension bushes - Introduction to random vibration - ISO road roughness and road profiles - RMS acceleration of sprung mass of vehicle for random road excitation.* *Practice 3: Magic Formula Tire model – Simulation of longitudinal and lateral forces.* *Practice 4: Simulation and analysis of Quarter Car model using Simulink / Simscape / Modelica.* *Case study to be offered by Volvo – Fundamental Equation of Motion for longitudinal dynamics of a truck* *Co Teaching Area / Content by Volvo - Longitudinal dynamics and Vertical Dynamics understanding in Complete Vehicle Model.*
Unit-3 - Lateral Dynamics and Vehicle Stability ***12 Hour***
General frame work for governing equations for ground vehicles - Bicycle Model- Low speed turning - High speed cornering-State space approach - Steady state handling characteristics of two axle vehicle- neutral steer-understeer-oversteer - Steady state gains from Bicycle Model during pure cornering - Vehicle handling tests (Constant radius cornering and fishhook) - Vehicle transient responses and understeer gradient effects due to lateral load transfer - roll steer - camber thrust - lateral force compliance and steering system compliance. On/Off center feel Homologation for steering system IS12222, IS11948. *Yaw plane stability and steering conditions - characteristic polynomial and stability factor – Handling response of a vehicle - Lateral transient response - Mimuro plot. Effect of suspension on cornering - Roll center and Roll axis - Roll moment distribution, ARB - Tyre relative angles - Caster theory - Role of suspension and nonlinearity of tyres on vehicle roll and its effect on Understeer co-efficient - roll over stability analysis - Control strategies required for vehicle.* *Practice 5: Shock absorber testing – Characterizing the shock absorber and formulating simple models for shock absorber using curve fitting.* *Practice 6: Control Strategy in ride modeling – Analysis of controllers like PID, Skyhook, LQR in ride comfort of vehicles using Simulink / Simscape / Modelica. Case study to be offered by Volvo – Quarter Car model formulation for a truck with cabin suspension and seat suspension.* *Co Teaching Area / Content by Volvo - Stability analysis of Trucks in Complete Vehicle Model.*
Unit-4 - Vehicle Dynamics for Electric, Hybrid and Autonomous Vehicles ***12 Hour***
introduction to EVs, HEVs, and AVs and their dynamics requirements - Dynamics behavior of the vehicle based on the battery pack location - Dynamics aspects based on the motor location and power distribution - NVH challenges for the EV and HEV- Experimental techniques - Frequency response functions - Modal analysis - Transfer path analysis - Single reference - Multi reference analysis. *Practice 7: Active Suspension system study using Quanser active suspension test rig. Practice 8:* *Control strategy for a basic ABS implementation using Simulink.* *Case study to be offered by Volvo – Bicycle model formulation for a truck system.* *Co Teaching Area / Content by Volvo - Differences in Complete Vehicle Model for Electric / Hybrid trucks when compared with Conventional trucks.*
Unit-5 - Modelling, Simulation and Advancements in Vehicle Dynamics Systems ***12 Hour***
ADAS, Role of ADAS, ADAS Levels, ADAS features - Adaptive Cruise Control, Adaptive Headlights, Antilock Brake Systems, Automatic Parking Assistance, Autonomous Emergency Braking, Blind Spot Monitor, Electronic Stability Control, Forward Collision Warning, Lane-departure Warnings, Lane-Centering Steering, Lane-keeping assistance. ISO 26262 – Overview. *Practice 9: Plotting longitudinal, lateral and vertical forces involved in vehicle motion using Carmaker software. Practice 10:* *Single Track model simulation and analysis using Simulink / Simscape.* *Practice 11: Basic kinematic Simulation with Motion Solve* *Case study to be offered by Volvo - Basic ABS system design for trucks* *Co Teaching Area / Content by Volvo - Simulation of trucks in Complete Vehicle Model*

Learning Resources	1. *J. Y. Wong, Theory of Ground Vehicles, 3rd Edition, Wiley-Interscience, 2008.* 2. *Thomas D Gillespie, Fundamentals of Vehicle Dynamics, 2nd Revised Edition, SAE International, Warrendale, 2021.* 3. *Reza N Jazar "Vehicle Dynamics: Theory and Application", 3rd Edition, Springer International Publishing AG, Switzerland, 2017.* 4. *Katsuhiko Ogata, "Modern Control Engineering",5th Edition, Prentice Hall,Pearson, 2015*	5. *C. Sujatha, "Vibration and Acoustics: Measurements and Signal Analysis", McGraw Hill Education (India) Private limited, 20178.* 6. *Ellis.J.R - "Vehicle Dynamics"- Business Books Ltd., London- 1991..* 7. *Giles.J.G.Steering - "Suspension and Tyres", Illiffe Books Ltd., London- 1998. Chalmers – Vehicle Dynamics, Chalmers publication Library.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*CLA-2 - practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Shantanu Chakraborty, Deputy General Manager, Volvo Group Trucks Technology, Banagalore.*	1. *Dr. V. Ganesh, Associate Professor, Dept. of Automobile Engineering, Sri Venkateswara College of Engineering, Pennalur.*	1. *Dr. AJD Nanthakumar, SRMIST*

Course Code	21AUC402J	Course Name	VEHICLE MAINTENANCE	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the fundamental workshop and maintenance concepts*
CLR-2:	*familiarize with the engine sub-systems nomenclature and maintenance*
CLR-3:	*understand the principles and construction of vehicle chassis and body*
CLR-4:	*familiarize with the operational characteristic of vehicle electrical system*
CLR-5:	*understand the concepts of various vehicle auxiliary system*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the workshop maintenance and practice*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*diagnose the various engine sub systems for engine maintenance*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze the performance characteristics of vehicle chassis and body*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*compare the operational characteristic of vehicle electrical system*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*analyze the maintenance schedule of various vehicle auxiliary system*	-	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-

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Unit-1 - Maintenance of Workshop Records and Schedule ***12 Hour***

importance of maintenance, scheduled and unscheduled maintenance, requirements of maintenance, preparation of check lists, vehicle down time, vehicle inspection, inspection schedule, maintenance of records, reports log books, trip sheets and other forms, safety precautions in maintenance, fleet maintenance requirement, work shop layout, tools and equipment, spare parts and lubricants stocking , manpower, training, workshop management, warranty, replacement policy.

Practice: *1. Layout for Garage and Preparation of Job Card Assignment (Two Wheeler/LCV/HCV), 2. Chart Preparation for Daily, Weekly, Monthly and Scheduled Maintenance*
3. Performance Evaluation of A Two-Wheeler Using Eddy Current Chassis Dynamometer

Unit-2 - Powertrain Maintenance ***12 Hour***

Dismantling of engine components and cleaning, cleaning methods, visual and dimensional inspections, minor and major reconditioning of various components, reconditioning methods, engine assembly, special tools used for maintenance and overhauling, engine tune up, layout of transmission system, servicing and maintenance of automobile clutch, servicing and maintenance of gear box, servicing and maintenance of propeller shaft, servicing and maintenance of differential system, troubleshooting checklist for engine, troubleshooting checklist for clutch, troubleshooting checklist gear box.

Practice: *4. Engine Tuning Process (Decarbonizing, Valve Lapping, Reboring, Valve Clearance and Shim Adjustment of Shafts), 5. Transmission System – Servicing and Maintenance (Clutch Gearbox Propeller Shaft Universal Joint and Slip Joint)*

Unit-3 - Vehicle Chassis and Body Maintenance ***12 Hour***

Maintenance and servicing of front axle, maintenance and servicing of rear axle, maintenance and servicing of suspension systems, maintenance and servicing of braking systems, overhauling of steering systems, maintenance of steering systems, wheel alignment, computerized alignment, wheel balancing, troubleshooting checklist for front axle, troubleshooting checklist for rear axle, troubleshooting checklist for suspension systems, troubleshooting checklist for steering systems, body panel tools for repairing, body panel tools for tinkering and painting.

Practice: *6. Steering System Servicing and Maintenance, 7. Tire Removal , Fitment, Computerized Wheel Alignment and Wheel Balancing 8. Determination of Side Slip, Suspension Efficiency, And Brake Efficiency Using Dynamometer.*

Unit-4 - Electrical System Maintenance	***12 Hour***
Testing methods for checking electrical components, checking of battery, checking of starter motor, checking of charging system, checking of, dc generator, checking of alternator, checking of ignition systems, checking of lighting systems, fault diagnosis of modern electronic controls, maintenance of modern electronic controls, checking of dash board instruments, servicing of dash board instruments, trouble shooting on engine management system, on board diagnosis using multi-scanner. ***Practice:*** *9. Measurement of HC, CO, CO2, and O2 Using Exhaust Gas Analyzer and Smoke Density Measurement* *10. Studying the Pattern of Secondary Ignition System Using Oscilloscope Type Engine Analyzer FSA 450 (Bosch)*	
Unit-5 - Maintenance of Auxiliary Systems	***12 Hour***
Servicing of fuel system of different types of vehicles, maintenance of fuel system of different types of vehicle, calibration and tuning of engine for optimum fuel supply, maintenance of cooling system, water pump, radiator, thermostat, anticorrosion and antifreeze additives, maintenance of lubrication system, different grades of oil, lubricant oil additive, lubricating oil changing, greasing of part, minor and major repairs of body parts, maintenance of door locking mechanism, maintenance of window glass actuating system. ***Practice:*** *11. Vehicle Assessment and Benchmarking of Tires by Tire Print Study, 12. Servicing of Coolant and Lubrication System.*	

Learning Resources	*1. MartyrA.J,PlintM.A, gine Testing Theory and Practice",3rdedition,Butterworth- Heinemann, 2007.Butterworth Heinemann, 2007.*	*2. Wolf-Heinrich Hucho, "Aerodynamics of road vehicles", 4th edition,2000* *3. Gousha H. M, "Engine Performance Diagnosis & Tune up Shop Manual".*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. P. Poongukamaran, MD TICEL md@ticelbiopark.com	*1. Dr. Ganesh V, Professor SVCE vinaganesh@svce.ac.in*	*1. Jerome Stanley M, SRMIST*
	2. Dr. Vijayabalan, Professor & Head Department ofMechanical Engineering HITS vijayabalan@hindustanuniv.ac.in	*2. Dr.K.Kamalakkannan, SRMIST*

Course Code	21MEC202T	Course Name	MECHANICS OF SOLIDS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*utilize concepts of stress and strain to determine the axial deformations*
CLR-2:	*construct the shear force and bending moment diagram, and determine the stresses in beams*
CLR-3:	*determine the slope and deflection in beams for various loading conditions*
CLR-4:	*utilize concepts to design shafts based on strength and rigidity*
CLR-5:	*utilize concepts to design column and cylinders to predict the failure conditions*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concepts of theory of linear elasticity*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze the force, bending moment and stresses in beams*	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze the slope and deflection in beams*	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*apply the concept of torsion in shafts*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*analyze the stresses in columns and pressure vessels*	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Concepts of Stress and Strain	***12 Hour***
Free body diagram, Types of stresses, strain, Poisson's ratio, stress-strain diagram, Elastic Constants, Deformation in axially loaded members, Strain energy, Impact loading, Thermal stresses- Stress at a point, Stress Tensor, Equations of Equilibrium, Different states of stress, Transformation of plane stress, Principal stresses and maximum shear stress - Mohr's circle for plane stress	
Unit-2 - Theory of Beams	***12 Hour***
Types of beams, support reactions, Shear Force Diagram, Bending Moment Diagram, Bending Stress & Shear stress in beams,	
Unit-3 - Deflection of Beams	***12 Hour***
Deflection of beams by double integration method- Macaulay's method-Moment area method-Castigliano's theorems, Maxwell's reciprocal theorem	
Unit-4 - Torsion of Shafts	***12 Hour***
Stresses in a Shaft, Deformations in a Circular Shaft, Stresses and Angle of Twist in the Elastic Range, Comparison of hollow and solid shafts	
Unit-5 - Columns and Pressure Vessels	***12 Hour***
Crippling load - Euler's theory and Rankine's theory, thin and thick pressure vessels, Lame's theory-case study on pressure vessels	

Learning Resources	1. *Ferdinand P. Beer, E. Russell Johnston, John T. DeWolf, David F. Mazurek, Sanjeev Sanghi, "Mechanics of Materials: 8th Edition" McGraw Hill, 2020* 2. *William A. Nash, Merle C. Potter, "Strength of Materials: 6th Edition, Schaum's Outlines Series, McGraw Hill Education, 2014*	3. *Egor P. Popov, Engineering Mechanics of Solid, 2nd ed., Prentice Hall of India Pvt. Ltd., 2009* 4. *James M. Gere, Mechanics of Materials, 8th ed., Brooks/Cole, USA, 2013* 5. *Shigley. J. E., Applied Mechanics of Materials, International Student edition, McGraw Hill, 2000*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. N. Babu, CVRDE, DRDO, Avadi, babu.n.cvrde@gov.in*	1. *Dr. Shankar Krishnapillai, IIT Madras skris@iitm.ac.in*	1. *Dr. E Vijayaragavan, SRMIST*
2. *Mr. Parameswaran, Nokia, Chennai parameswaran.s@nokia.com*	2. *Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	2. *Dr. A Vinoth, SRMIST*

Course Code	21MEC202L	Course Name	MATERIAL TESTING LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the specimen preparation procedures and correlate structure-property relationship of ferrous and non-ferrous alloy specimens*
CLR-2:	*acquire knowledge to perform grain size analysis and determine coating thickness and hardenability*
CLR-3:	*evaluate the variation in hardness and microstructure of heat-treated steel specimens and also to understand the tensile characteristics and deflection of materials*
CLR-4:	*have a better understanding on the mechanical behaviour of materials under compression, double shear, three-point bend and torsional loads*
CLR-5:	*understand the behaviour of materials subjected to fatigue, impact loads and to know the procedure of wear analysis*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*prepare different metal specimens and identify specimens by examining their microstructures*	-	-	-	3	-	-	-	-	1	-	-	-	-	-	-
CO-2:	*determine hardenability, coating thickness and analyze microstructure*	-	-	-	3	2	-	-	-	1	-	-	-	-	-	-
CO-3:	*investigate the variation in hardness and microstructures of heat-treated specimens and study their tensile characteristics and deflection of simply supported beams*	-	-	-	3	-	-	-	-	1	-	-	-	-	-	-
CO-4:	*Analyze the mechanical behaviour of materials subjected to compression, double shear, three- point bend and torsion loads*	-	-	-	3	-	-	-	-	1	-	-	-	-	-	-
CO-5:	*evaluate fatigue, impact and wear characteristics of materials*	-	-	-	3	-	-	-	-	1	-	-	-	-	-	-

Unit-1 - Specimen Identification	***6 Hour***
Study of metallurgical microscope, specimen preparation - mounting, polishing, etching. Identification of ferrous and non-ferrous alloys.	
Unit-2 - Coating Thickness and Phase Fraction	***6 Hour***
Determination of coating, case hardening thickness, hardenability. Evaluation of grain size and phase fraction.	
Unit-3 - Heat Treatment, Microstructure and Tensile Properties	***6 Hour***
Heat-treated steel specimens - investigation of microstructure and hardness. Tensile behaviour of steel specimens, deflection of simply supported beams.	
Unit-4 - Compression, Shear, Flexural and Torsion Properties	***6 Hour***
Compression, double shear, three-point bend and torsion tests of materials	
Unit-5 - Fatigue, Impact and Wear Properties	***6 Hour***
Fatigue test, impact test, wear analysis - pin-on-disc apparatus	

Learning Resources	1. *Sidney H Avnar, Introduction to physical metallurgy, 2nd ed., McGraw Hill Education, 2017* 2. *Donald R. Askeland, Wendelin J. Wright, Science and Engineering of Materials, 7th ed.,Cengage Learning, 2015*	3. *Ferdinand Beer, E. Russell Johnston, Jr., John DeWolf, David Mazurek, Mechanics of Materials, 7th ed., McGraw - Hill, 2017* 4. *Kazimi S. M. A, Solid Mechanics, 2nd ed.,Tata McGraw Hill, 2017* 5. *Laboratory Manuals - Metallurgy & Strength of materials laboratories*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*15%*	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	-	*25%*	-	*20%*	-	*25%*	-	-
Level 3	*Apply*	-	*30%*	-	*25%*	-	*30%*	-	-
Level 4	*Analyze*	-	*30%*	-	*25%*	-	*30%*	-	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-	-	-
Level 6	*Create*	-	-	-	*5%*	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Shankar Subburathinam, Engineering Manager – Caterpillar India Ltd*	1. *Dr. A. Suresh Babu, Associate Professor, CEG - Anna University*	1. *Mr. D. Selwyn Jebadurai,AP, SRMIST*
2. *Dr. N Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability, Mahindra Research Valley.*	2. *Dr. N. Arunachalam, Associate Professor, IITM*	2. *Mr. S. Arokya Agustin,AP, SRMIST*

Course Code	21MEC203T	Course Name	ENGINEERING MATERIALS AND METALLURGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*acquire knowledge about phase diagrams, salient features of iron-carbon system and heat treatment process*
CLR-2:	*apply mechanism of plastic deformation, principle of strengthening methods*
CLR-3:	*utilize the mechanical behavior of materials and learn about failure analysis*
CLR-4:	*identify about structure, properties and applications of metals and non-metals*
CLR-5:	*acquire knowledge about properties and applications of advanced engineering materials*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret binary phase diagram, describe the micro-constituents in iron-carbon system effect of heat treatment and surface hardening on the properties of materials*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*explain different strengthening mechanisms, concepts related to plastic deformation*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*discuss the failure of engineering materials, material testing and characterization techniques*	*1*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*classify metals and non-metals for various engineering applications*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*apply advanced materials for specific applications based on their properties and describe computational methods related to materials*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Phase Diagram and Heat Treatment — ***9 Hour***

Crystal structure, Imperfection in solids, Solid solutions – Types, factors governing solubility rules. Phase diagram – cooling curve, phase rule, types and interpretation. Iron- carbide (Fe-Fe3C) phase diagram, Microstructural aspects and invariant reactions in Fe-Fe3C diagram. Effect of alloying elements on Fe-Fe3C diagram. TTT and CCT diagrams. Various heat treatment and surface hardening process

Unit-2 - Elastic and Plastic Behaviour of Materials — ***9 Hour***

Stress Strain relation in elastic and plastic region, Mechanism of plastic deformation – slip and twinning, Slip systems, critically resolved shear stress, Shear strength of perfect and real crystals. Dislocation – climb, interaction, multiplication and pile ups. Strengthening mechanisms – Solid solution, Grain boundary, Dispersion, Precipitation, Fiber, Martensite strengthening, Strain aging and Strain hardening.

Unit-3 - Failure, Testing and Characterization of Materials — ***9 Hour***

Types of fracture in metals, Griffith's theory of brittle fracture, Stress intensity factor, Fracture toughness, Theory of Ductile to brittle transition. Creep – Creep curve, mechanism of creep deformation. Fatigue - S-N curve, low and high cycle fatigue, stages of fatigue. Sources of failure, Procedure of failure analysis. Hardness: Rockwell, Brinell, Vickers hardness, Nano-Indentation Technique. Introduction to characterization of materials - XRD, SEM and TEM.

Unit-4 - Properties of Advanced Materials — ***9 Hour***

Properties of plain carbon steel, Tool steel, Stainless steel, Cast iron. Need of micro alloying, HSLA steel - Dual phase steel, TRIP steel. Aluminum alloys – classifications, properties, applications, Titanium alloys. Polymers – Types, Properties and applications of PE, PP, PVC. Ceramics – Types, Properties and applications of Al2O3, ZrO2, SIC. Composites – classification, Reinforcement and matrix material, Rule of Mixture. Properties and applications of MMC, CMC and PMC. Functionally graded materials.

Unit-5 - Futuristic Materials and Computational Materials Design — ***9 Hour***

Smart materials – Types, Shape memory alloys. Nanomaterials: Carbon nanotubes, Graphene – properties and applications. Metallic foams, Metallic glasses, Super alloys, High entropy alloys, biomaterials, Multi-scale materials modelling. Integrated Computational Materials Engineering with application to Industry 4.0. Materials Informatics, Machine learning for design of materials, Property Optimization

Learning Resources	1. *Flake.C Campbell, Elements of Metallurgy and Engineering Alloys, ASM International, 2008* 2. *Dieter.G.E, Mechanical Metallurgy, McGraw Hill, Singapore, 2017* 3. *Budinski.K.G, Budinski.M.K, Engineering Materials Properties and selection,Edition 9, Pearson Publication, 2010* 4. *ASM Hand book, Failure analysis and prevention, Vol: 11, 2021* 5. *Reza Abbaschian, Lara Abbaschian& Robert E. Reed-Hill, Principles of Physical Metallurgy, Cengage Learning, 2013* 6. *Chaudhery Mustansar Hussain,,"Smart Materials and New Technologies", Springer, 2022* 7. *Shubhabrata Datta and J. Paulo Davim, Machine Learning in Industry, Springer, 2021.*	8. *James F. Shackelford et.al. CRC Materials Science and Engineering Handbook, Taylor & Francis, 2015.* 9. *William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction,10th ed., Wiley publication, 2018* 10. *Donald R. Askeland, Wendelin J. Wright, Essentials of Materials Science & Engineering, 4th ed., Cengage, 2018* 11. *Raghavan V. Physical Metallurgy: Principles and Practice, PHI Learning, 2015.* 12. *Shubhabrata Datta and J. Paulo Davim, Materials Design Using Computational Intelligence Techniques, CRC Press, Boca Raton, FL, USA, 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr.V.S.Saravanan , Indo Shell Cast Private Limited, saravananvs@indoshellcast.com*	1. *Dr. Raju Abraham, Scientist-F, National Institute of Ocean Technology, Velachery-Tambaram Road, Pallikaranai, Chennai 601302, abraham@niot.res.in*	1. *Dr. Shubhabrata Datta, SRMIST*
2. *Mr. R.Sadagobaramanujam, TVS Sundram Fasteners Ltd, sadagobar@gmail.com*	2. *.Dr. N Arunachalam, IIT Madras, chalam@iitm.ac.in*	2. *Mr.M.Dhanasekaran, SRMIST*

Course Code	21MEC204L	Course Name	FLUID MECHANICS LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*identify the flow measuring devices*
CLR-2:	*apply the principles of Bernoulli's equation*
CLR-3:	*analyze the various energy losses in pipes*
CLR-4:	*assess the working of pumps/ Turbines*
CLR-5:	*measure forces around streamline body/bluff body in wind/ water tunnel*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*demonstrate the coefficient of discharge in flow measurement devices*	*3*	-	-	-	-	-	-	-	*3*	-	-	-	-	-	-
CO-2:	*identify Bernoulli's equation for measuring different heads*	*3*	-	-	-	-	-	-	-	*3*	-	-	-	-	-	-
CO-3:	*determine and analyze the various energy losses in pipes*	*3*	-	-	-	-	-	-	-	*3*	-	-	-	-	-	-
CO-4:	*interpret the different types of pumps/turbines based on its performance*	*3*	-	-	-	-	-	-	-	*3*	-	-	-	-	-	-
CO-5:	*perform forces measurement around streamline body/bluff body in wind/ water tunnel*	*3*	-	-	-	-	-	-	-	*3*	-	-	-	-	-	-

Unit-1 - Flow Measuring Devices	***6 Hour***
Determine the coefficient of discharge of Orifice meter/ Venturimeter, Flow measurement using Pitot tube	
Unit-2 - Bernoulli's Principle	***6 Hour***
Determine total heads of fluids at given points in the pipe/ Bernoulli's theorem, forced vortex and find the depth of the forced vortex curve	
Unit-3 - Energy Losses in Pipes	***6 Hour***
Study of major Energy loss in a pipe, Study of Minor losses due to pipe fittings and bends	
Unit-4 - Pumps and Turbines	***6 Hour***
Performance test on Submersible pump/ Reciprocating Pump/ Jet pump/ Gear Pump, Performance test on Pelton turbine/ Kaplan turbine/ Francis turbine	
Unit-5 - Wind and Water Tunnels	***6 Hour***
Velocity and pressure measurement using pitot tube, hot wire Anemometry and pressure sensor, model mounting technique, Force calculations	

Learning Resources	
	1. *Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, Introduction to Fluid Mechanics, 8thed., Wiley,2013*
	2. *Frank M. White, Fluid Mechanics,7th ed., McGraw-Hill,2018*
	3. *P.N.Modi,S.M.Seth,Hydraulics&FluidMechanicsIncludingHydraulicsMachines,20thed.,Standard Book House,2018*
	4. *KL Kumar., Engineering Fluid Mechanics,10th ed.,S Chand&Co.,2015 Laboratory Manual*

Learning Assessment									
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	30%	-	30%	-	30%	-	-
Level 2	Understand	-	30%	-	30%	-	30%	-	-
Level 3	Apply	-	40%	-	40%	-	40%	-	-
Level 4	Analyze	-	-	-	-	-	-	-	-
Level 5	Evaluate	-	-	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-	-	-
	Total	100%		100%		100%		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Er. N. Palani, Scientist D/SAMEER – Chennai.	1. Dr. Dhiman Chatterjee, IIT Madras, Chennai, dhiman@iitm.ac.in	1. Dr. Pankaj Kumar, SRMIST
2. Er.D. Harihara Selvan,Technical Leader, GE Power,Noida - 201301	2. Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in	2. Dr. Santosh Kumar Singh, SRMIST

Course Code	21MEC205T	Course Name	FLUID MECHANICS AND MACHINERY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*utilize the properties of fluid and pressure measurement techniques using manometer*
CLR-2:	*utilize the basic equations of fluid mechanics to solve fluid flow problems*
CLR-3:	*utilize the applications of dimensional and model analysis*
CLR-4:	*utilize the concept of boundary layer, lift and drag forces*
CLR-5:	*identify the working principle and design of hydraulic turbines and pumps*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*determine the properties of fluid*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*solve the fluid flow problems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply the mathematical techniques for practical fluid flow problem*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze the boundary layer theory and flow over submerged bodies*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*identify the energy exchange process in fluid machinery*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Fluid Properties and Fluid Statics	***9 Hour***
Types of fluids, Properties of fluid, Dynamic and Kinematic viscosity - Newton's law of viscosity- Surface tension and capillarity- -Bulk modulus of elasticity and compressibility, Fluid statics: Pascal's law, Hydrostatic law, Buoyancy and Meta centre, Pressure, Manometers - Piezometer- Applications and limitation - U-Tube, Single column, Differential U-tube, Inverted differential U-tube manometers.	
Unit-2 - Fluid Kinematics and Dynamics	***9 Hour***
Types of fluid flow, Lagrangian and Eulerian approach, Velocity and acceleration of fluid particles- Continuity equation- Euler equation of motion-Bernoulli's equation- Applications - Venturimeter- Orificemeter -Pitot tube-Nozzle flow meter- Types of flow lines, Stream line-Streak line and Path line-Impulse Momentum equation.	
Unit-3 - Dimensional Analysis and Flow Through Pipes	***9 Hour***
Dimensions, Dimensional homogeneity-Buckingham's pi theorem-Model analysis-advantages and applications-similitude, Dimensionless numbers-Model laws- Reynold's, Froude, Weber, Mach, and Euler model laws, Concept of fully developed pipe flows - Darcy equation –Major and minor losses-Pipes connected in series and parallel-Equivalent pipe.	
Unit-4 –Boundary Layer and Flow Around Submerged Bodies	***9 Hour***
Flow over flat plate - Laminar and turbulent boundary layers - Von Karman momentum integral equation - Boundary layer thickness – Displacement, momentum and energy thickness - Forces exerted by a flowing fluid on a stationary bluff and streamlined bodies -Separation of flow over bodies - Development of lift and drag forces.	
Unit-5 - Hydraulic Machines	***9 Hour***
Pumps and turbines - Classification - Centrifugal and reciprocating pumps - Working principle - Design parameters -Velocity triangle - Performance curves – Pelton turbine, Francis turbine and Kaplan turbine, - Working principle - Design parameters - Velocity triangle – Performance curves - Cavitation in pumps and turbines.	

Learning Resources	1. *Rajput.R.K, A text book of Fluid Mechanics and Hydraulic Machines, S.Chand& Company Ltd., 6th ed., 2015* 2. *Bansal.R.K, A text book of Fluid Mechanics and Hydraulics Machines, Laxmi publications (P) Ltd., 9th ed., 2015* 3. *Modi P.N, Seth S.M, Hydraulics and Fluid Mechanics, Standard Book House, 15th ed., 2002* 4. *Streeter.V.L, Wylie.E.B, Fluid Mechanics , McGraw Hill, 5th ed., 1984*	5. *Robert W. Fox & Alan T. McDonald & Philip J. Pritchard, Introduction to Fluid Mechanics, John Wiley & Sons Inc. 8TH ed 2011* 6. *Cengel, Y.A. and Cimbala, J.M. (2018) FluidMechanics. Fundamentals and Applications. 4th Edition. McGraw-Hill, New York.* 7. *White.F.M, Fluid Mechanics, Tata McGraw-Hill, 7th ed., 2011*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Er. N. Palani, Scientist D/SAMEER – Chennai.*	1. *Dr.S.Mohammed Ibrahim, IITKanpur*	1. *Dr.R.Senthil Kumar, SRMIST*
2. *Er.D. Harihara Selvan,Technical Leader, GE Power,Noida - 201301*	2. *Dr.S. Jayavel, IITDM, Kancheepuram*	2. *Dr.V. Rajasekar, SRMIST*

Course Code	21MEC206T	Course Name	KINEMATICS AND DYNAMICS OF MACHINES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*apply the kinematic analysis concepts to familiarize the working principle of machine tools*
CLR-2:	*familiarize the IC engine's valve and port mechanism and design the gear-box for power transmission systems*
CLR-3:	*apply the concepts of static and dynamics forces in IC engines and flywheels*
CLR-4:	*familiarize the balancing of forces and moments in rotor bearings, ships and aeroplanes*
CLR-5:	*familiarize the fundamentals of vibrations in Single degree of freedom systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concepts of theory of mechanisms to perform kinematic analysis*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze the kinematics of cam and follower, and gear trains*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*perform the static and dynamic force analysis of mechanisms*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze the effect of unbalancing forces and gyroscopic effects in machines*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*formulate the governing equations and solve for single DOF systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Kinematics of Mechanisms	***9 Hour***
Introduction to mechanism: Link, pair, kinematic chain, mechanism and machine - Degrees of Freedom - Mobility - Four Bar Chain, Grashof's law, Kutzback's and Grubler's criterion for planar mechanisms - Kinematic Inversions of kinematic chain, Kinematic Analysis: Velocity and acceleration analysis of Four bar and single slider crank mechanism by graphical method - Instantaneous center (IC) method, Kennedy's theorem, Velocity analysis of Four bar and single slider crank mechanism by Instantaneous center method	
Unit-2 - Kinematic Analysis of Machine Elements	***9 Hour***
Cams and Followers: Cam terminology, types of cams and followers, Types of follower motion - Kinematics of follower for parabolic, simple harmonic, uniform acceleration and cycloidal motions - construction of circular cam profile for radial and offset followers with different follower motions Gears: Gear terminology, types of gears - law of gearing - path of contact, arc of contact, sliding velocity - interference and undercutting of gears – Gear trains: types and applications - velocity ratio calculations in simple, compound and epicyclic gear train	
Unit-3 - Force Analysis	***9 Hour***
Applied and Constrained Forces – Free body diagrams – Static Equilibrium conditions – Two, Three and four force members – Static Force analysis in simple machine members – Dynamic Force Analysis – Inertia Forces and Inertia Torque – D'Alembert's principle – superposition principle – dynamic force Analysis in reciprocating engines - Turning moment diagrams - flywheels- Case study on four bar mechanism	
Unit-4 - Balancing and Gyroscope	***9 Hour***
Balancing of rotating masses: Static and dynamic balancing of several masses rotating in same and different planes by analytical and graphical methods - Balancing of reciprocating masses by graphical method. Gyroscope: Gyroscopic forces, couple, precessional angular motion, Gyroscopic effects on automobiles, trains, aeroplane and ship	
Unit-5 - Fundamentals of Vibrations	***9 Hour***
Basics of vibrations - Terminology and types of vibrations - Governing equations for free undamped and damped vibrations of single degree of freedom system - logarithmic decrement. Forced vibration: Types of - of forced vibration single degree of freedom system under harmonic excitation.	

Learning Resources	1. *Rattan S.S., "Theory of Machines ", McGraw Hill Education, 4th edition, 2015* 2. *Thomas Bevan, Theory of Machines, 3rd Edition – P* 3. *Education Limited – 2005 – 3rd Edition*	4. *Robert L. Norton, Kinematics and Dynamics of Machinery, 2nd Edition, McGraw Hill, 2013.* 5. *Rao SS, 'Mechanical Vibrations, 5th Edition, Prentice Hall*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. N. Babu, CVRDE, DRDO, Avadi, babu.n.cvrde@gov.in*	1. *Dr. Shankar Krishnapillai, IIT Madras, skris@iitm.ac.in*	1. *KR. Arun Prasad, SRM IST*
2. *Mr. Parameswaran, Nokia, Chennai, parameswaran.s@nokia.com*	2. *Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	

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ACADEMIC CURRICULA

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Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21AUE202T	Course Name	SENSORS, ACTUATORS AND SIGNAL CONDITIONERS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	define the sensors, their operations and select appropriate sensors for automotive applications
CLR-2:	define and classify the actuators and select to integrate them into an overall system
CLR-3:	identify signal conditioning operations and devices
CLR-4:	evaluate and analyze the sensor signals
CLR-5:	compare the input signals and select appropriate data conversion methods

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	acquire the knowledge of construction and operation of sensors and its applications in automobiles	3	3	1	-	1	-	-	-	-	-	-	1	3	-	-
CO-2:	understand the basics of actuators and its operations	3	3	2	-	2	-	-	-	-	-	-	1	2	1	-
CO-3:	know the fundamentals of signal conditioning devices and its operation	3	3	2	-	2	-	-	-	-	-	-	1	3	-	-
CO-4:	applications of operational amplifier and its applications	3	3	2	-	2	-	-	-	-	-	-	1	3	-	-
CO-5:	learn and implement the basics of data conversion devices	3	3	2	-	2	-	-	-	-	-	-	1	3	-	-

Unit-1 - Automotive Sensors	9 Hour
introduction to sensors, variables to be measured for automotive engine control applications, airflow rate sensor – construction and operations, pressure measurement – strain gauge and map sensor, engine crank position sensor - -magnetic reluctance, hall effect sensor, optical crank position, throttle angle sensor – construction and operation, construction and operation, temperature sensor construction and operations and types, sensors for engine feedback control - ego sensor, ego characteristics, wide band lambda sensor, magnetostrictive principle and knock sensor, oil pressure sensors, accelerometer construction and operations, gyro sensors construction and operations, inertial measurement unit, sensors for climate control, switches and knobs313	
Unit-2 - Automotive Actuators	**9 Hour**
basics of actuators and its principles of operations, variables to be controlled for automotive engine control applications, pulse width modulated signal, h-bridge device for speed and direction control, electric motor actuator - dc motor, brushless dc motor, stepper motor mechanism, servomechanism, engine control actuators -fuel injector, ignition coil operation, egr actuator operation, electric actuators – overview, relays, reed switches – construction and operation, actuators applications, electric power assisted steering, rain sensing wipers, motorized seat position control, power window application	
Unit-3 - Introduction to Operational Amplifier	**9 Hour**
Introduction – Signal conditioning operations, Basics of operational amplifier, Ideal operational amplifier – Introduction, characteristics, Operational amplifier- open and closed loop, Operational amplifier- Inverting, Non- Inverting amplifier, Voltage follower; Differential amplifier - Difference mode gain, Common mode gain, Common Mode Rejection Ratio; Operation amplifier internal circuit, DC characteristics of operational amplifier, IC 741 internal circuit Introduction, IC 741 Operations, Filters – Introduction, High pass and low pass Filter, Band pass Filter	
Unit-4 - Operational Amplifier Applications	**9 Hour**
Applications of operational amplifiers, Basics of Instrumentation amplifiers, Operational amplifier using diodes- Half wave Rectifier, Full wave rectifiers, Precision diodes; Sample and Hold circuits, Voltage to Current converters, Current to Voltage converters, Applications of operational amplifiers as Adder, Subtractor,Multiplier, divider, Differentiator and Integrator, Instrumentation amplifier application, Voltage comparator, Peak detector	

Unit-5 - Waveform Generators, A/D And D/A Convertors	***9 Hour***
Comparator introduction, Comparator Applications, Regenerative Comparator Introduction, Square Wave Generator - Astable Multivibrator, Monostable Multivibrator and Bistable Multivibrator Introduction to Analog to Digital Converters, Types of Analog to Digital Converters – Direct TypeADC, Flash Type, Successive approximation type, Numerical Examples for ADC; Basics of Digital to Analog Conversion Techniques – R-2R Ladder DAC , Inverted R-2R Ladder DAC, Weighted Resistor type DAC, Numerical Examples.	

Learning Resources		
	1. *William. B. Ribbens, "Understanding Automotive Electronics" 8th Edition Butterworth-Heinemann publications, 2017.* 2. *Ronald. K. Jurgan "Automotive Electronics Handbook", 2ndEdition, McGraw-Hill, Inc 2005* 3. *Robert F. Coughlin, Frederick F. Driscoll, "Operational Amplifiers and Linear Integrated Circuits", 6th Edition, PHI, 2000.*	4. *D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New AgeInternational Pvt. Ltd., 4th edition, 2018.* 5. *Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 3rd Edition, Tata Mc Graw-Hill, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Jegan Amirthalingam, Associate Director, Skill- Lync*	1. *Mr. Sam Jebakumar, SRMIST, jebakumj@srmist.edu.in*	1. *Dr.C.Carunaiselvane, SRMIST*
2. *Mr.G.Giri, Managing Director, Atalon , giri@atalon.co.in*	2. *Dr. SathishKumar. P, Assistant Professor, sathish.p@nitpy.ac.in, NIT, Karaikal*	2. *Dr.T.Praveenkumar, SRMIST*

Course Code	21AUE211J	Course Name	ANALOG AND DIGITAL CIRCUITS FOR AUTOMOTIVE APPLICATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes / Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	acquire knowledge about the BJT, MOS based amplifiers
CLR-2:	know the working of oscillator, wave Shaper and Multi vibrator circuits
CLR-3:	impart the techniques of minimizing digital logic circuits
CLR-4:	familiarize the combinational circuits for different digital applications
CLR-5:	familiarize the digital sequential circuits and memory devices

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	understand the use of analog circuits that are essential for Automotive Application	3	2	1	-	2	-	-	-	1	1	-	1	3	-	-
CO-2:	understand the Oscillators, Wave Shaping and Multi Vibrator Circuits	3	3	1	-	2	-	-	-	1	1	-	1	3	-	-
CO-3:	apply the Boolean expression minimization techniques and implement using logic gates	3	3	1	-	2	-	-	-	1	1	-	1	-	2	-
CO-4:	design and implement the Combinational Circuits	3	3	1	-	2	-	-	-	1	1	-	1	3	-	-
CO-5:	design and implement Sequential Circuits and understand the Memory Devices	3	2	1	-	2	-	-	-	1	1	-	1	3	-	-

Unit-1 - Introduction to Analog Circuits **12 Hour**

Introduction to Analog circuits, BJT Small signal Model, CMOS Circuit Model, CMOS Circuit Mode, Biasing Circuits, MOS amplifiers, Frequency response of amplifiers, Operational amplifiers. Differential amplifiers, Application of amplifiers in Automobile.

***Practice** 1: Operation of BJT and CMOS as amplifier 2: Characteristic of Op Amp*

Unit-2 – Oscillator Wave Shaping and Multivibrator Circuits **12 Hour**

Oscillator: Introduction, Analysis of LC oscillator, Wave shaping: RC and RL Filters, Differentiator, Integrator, Clippers, Clamper, Comparator, UJT-Saw tooth Waveform Generator, Multivibrators: astable, Monostable and Bistable, Schmitt trigger circuits.

***Practice** 3: Study and Design of Filters 4: Study and Design of multivibrators*

Unit-3 - Logic Gates and Arithmetic Application **12 Hour**

Logic circuit implementation: AND, OR, NOT, NAND, NOR, EXOR, EX-NOR, TTL Logic, CMOS Logic, Arithmetic application: Boolean Postulates,Demorgan's Theorem, , Min term, Max term, POS,SOP form, K-MAP – Overview,

***Practice** 5: Study of Logic Gates through Basic Digital IC's 6: Minimization of Boolean Expression using K map*

Unit-4 - Combinational Circuits **12 Hour**

Introduction to Combinational Circuit, Arithmetic and logic functions: Adder and Subtractor operation and circuit example, Serial adder/Subtractor, BCD addition, Data transmission: Multiplexer, Demultiplexer, Decoder, Encoder, Parity Checker, Parity Generator, Code Convertor.

***Practice** 7: Combination Logic Adder, Subtract or, Differentiator Circuits 8: Circuit realization of UX, DEMUX 9: Circuit realization of Code Converter.*

Unit-5 - Sequential Circuits and Memory Devices	***12 Hour***
Latches and Flip-flops: SR, JK, D, T characteristic table and Equation, Counters: Asynchronous Counters, Synchronous Counters, ProgrammableCounters. Registers: Shift Registers, Universal Shift Register, and Sequence Generator, Memory Devices: RAM, ROM, PROM, EPROM, EEPROM, Programmable Logic Devices: PLA VS PLD, Introduction to FPGA.	
***Practice** 10: Circuit realization of Flip-flops*	

Learning Resources	1. *David A.Bell "Electronic Devices and Circuits", Oxford HigherEducation Press, 5th Edition, 2010* 2. *M. Morris Mano, "Digital Design", 5th Edition, Prentice Hall of India Pvt. Ltd., 2014 / Pearson Education (Singapore) Pvt. Ltd.,New Delhi.*	3. *Donald P.Leach and Albert Paul Malvino, "Digital Principles andApplications", 6th Edition, TMH, 2006.* 4. *Sedra and Smith, "Micro Electronic Circuits"; 7th Edition, Oxford University Press, 2011. Millman and Halkias. C., Integrated Electronics, TMH, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*-*	*25%*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*-*	*30%*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Jegan Amirthalingam, Associate Director, Skill- Lync*	1. *Dr.S.Jeevananthan, Professor, Electrical and Electronics Engineering, PTU, drsj_eee@pec.edu.in*	1. *Dr.C.Carunaiselvane, SRMIST*
	2. *Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu*	2. *Dr.T.Praveenkumar, SRMIST*

Course Code	21AUE371T	Course Name	VEHICLE DYNAMICS AND DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	broaden the importance of vehicle performance characteristics
CLR-2:	enable the students to understand various automotive vehicle stability, ride and handling
CLR-3:	assist the students to know about Dynamic Characteristics of a Vehicle
CLR-4:	enable the students to understand various Convenience System
CLR-5:	enable the students to understand various methods in Automotive Styling

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	acquire and analyze the various factors that affect the vehicle performance	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-2:	characterize various conditions as Vehicle Stability, Ride & Handling	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	demonstrate Dynamic Characteristics of Vehicles	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-4:	discuss about Convenience System with their challenges and its applications	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-5:	apply knowledge of vehicle styling	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Vehicle Performance Estimation and Prediction — **9 Hour**

Aerodynamic Drag, Methods of Estimation Of Resistance To Motion, Power Requirement For Propulsion, Power Plant Characteristics & Transmission Related Requirements. Vehicle Controls and Arrangement Of Power Train. Vehicle Acceleration, Maximum Speed, And Grade Ability. Drive Systems Comparisons, Hill Climbing Characteristics. Ride Characteristics On Different Road Surfaces, Effect Of Pressure, Temperature And Humidity On Power Output

Unit-2 - Vehicle Stability and Handling — **9 Hour**

Introduction to Electric Vehicles, Wiring Diagram/ Power Flow in EVs & HEVs z, Wiring Diagram/ Power Flow in EVs & HEVs , Types of EVs: HEV, FCEV, HEVs Configuration: Series- Case Study, HEVs Configuration: Parallel - Case Study, HEVs Configuration: Series Parallel- Case Study, Motor, Battery Pack, DC-DC Convertor, Inverter, On-Board Charger , Communication System, smart hybrid technology - NEXA, Micro Hybrids - Case Study Electric Vehicle Charging- Fundamentals, Single and Multi-motor drives, In wheel drives

Unit-3 - Vertical Dynamics — **9 Hour**

List the methods for assessing human tolerance to vibration, Describe the criteria for ride comfort, Categorize the vertical dynamics modeling of vehicles, Evaluate the equation of motion for the vertical dynamic models, Design passive suspension system in quarter car model, Analyze passive suspension system in quarter car model, Design semi active and active suspension systems in quarter car model, Analyze semi active and active suspension systems in quarter car model, Design passive suspension system in half car model, Analyze passive suspension system in half car mode, Design semi active and active suspension systems in half car model, Analyze semi active and active suspension systems in half car model Apply the PID control strategy to automotive suspension systems, Apply the skyhook and LQR control strategy to automotive suspension systems

Unit-4 - Convenience System — **9 Hour**

Antiskid Braking System, Traction Control System, Adaptive Cruise Control, Driving Assistance System- Electronic All-Around Visibility, Parking Aid With Ultrasonic Sensors, Environment Information System, Driver Alertness Detection System, design Of Seat Belt, Automatic Seat Belt Tightening System, Collapsible, Tilt-Able Steering System Design, The Design, Construction Of Air Bags

Unit-5 - Automotive Styling	***9 Hour***
Fundamentals of drawing perspective, aesthetics, ergonomics, anthropometry, vehicle proportions, styling process, sketching, clay modeling, rendering, digital visualization, designing of Interiors: R/H-Point, seating positioning, dash board equipment's arrangement, positioning of operational controls, visibility and vehicle packaging.	

Learning Resources	1. *Reza N. Jazar, "Vehicle Dynamics: Theory and Application", 3rd Edition, Springer International Publishing AG, Switzerland, 2017.* 2. *Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics (R114) Publisher: Society of Automotive Engineers Inc., 1992.* 3. *William F. Milliken and Douglas L. Milliken, "Race Car Vehicle Dynamics", SAE, 1995.* 4. *Rajesh Rajamani- "Vehicle Dynamics and Control"- 1st edition- Springer- 2005.*	5. *W.H. Hucho, 'Aerodynamics of Road Vehicles', SAE Publications, 6th edition 2012* 6. *R.McCallen, Browand, Ross, "The Aerodynamics of Heavy Vehicles", Springer, 2014* 7. *Pope "Wind Tunnel Testing"- John Wiley & Sons - 2nd Edition, New York - 1974.* 8. *Julian Happian-Smith, "An introduction to modern vehicle design", Butterworth Heinmenn, 2001* 9. *Fenton John, "Handbook of automotive body and system design", Wiley-Blackwell, 1998* 10. *R.N. Bahl, "Automobile Design", Wiley.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr.Mohammed Rafiq, ARAI*	1. *Dr. P. Sathish Kumar NIT - Karaikkal*	1. *Mr. M.Jerome Stanley SRMIST*
		2. *Mr. Yokeshwaran S SRMIST*

Course Code	21AUE411T	Course Name	POWER ELECTRONICS FOR ELECTRIC VEHICLE APPLICATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	define and understand the power semiconductor components and its characteristics
CLR-2:	distinguish and demonstrate the different DC-DC and AC-AC converters topology
CLR-3:	interpret and relate the operation, characteristics and performance parameters of rectifiers
CLR-4:	compare and contrast the operation, switching techniques for various types of DC-AC inverters
CLR-5:	design and develop the motor drives for automotive motor control applications

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	list and recognize the various power semiconductor devices suitable for motor drive applications	3	1	-	-	-	-	-	-	-	-	-	-	3	-	2
CO-2:	identify and solve the DC-DC and AC-AC converters suitable for the desired requirements	3	2	2	1	-	-	-	-	-	-	-	-	3	-	2
CO-3:	experiment and sketch the various AC-DC Rectifier configurations and their input and output Waveforms	3	2	2	1	-	-	-	-	-	-	-	-	3	-	2
CO-4:	relate and use the DC - AC Inverters with various sources and control techniques	3	2	2	1	-	-	-	-	-	-	-	-	3	-	2
CO-5:	investigate and select the various motor drives suitable for the desired applications	3	2	2	1	-	-	-	-	-	-	-	-	3	-	2

Unit-1 - Automotive Semiconductor Devices — **9 Hour**

Introduction to power semiconductor devices, Diodes: Construction, characteristics and applications – Rectification, Diodes – Freewheeling, Diodes – Clamping Devices, Transistors: BJT, Power MOSFETs, and - Low-Voltage Load Drivers, IGBTs: Construction, characteristics and applications. Operation parametrization: Turn ON and Turn OFF techniques, Series and Parallel operation Power Integrated Circuits, Power Integrated Circuits Examples, Smart Power Devices, Emerging Device Technologies - Super- Junction, Emerging Device Technologies - Sic Devices, Protection circuit, Power Losses and Thermal analysis in semiconductors, Interpretation of data sheets.

Unit-2 - Chopper — **9 Hour**

Chopper circuit – Construction, Operation and Types, DC chopper: Buck, Boost, and Buck-Boost Converter: Construction, Principle of Operation and Characteristics – Duty cycle, Control strategies: Variable and constant frequency- Bi-directional operation, overview, Buck, Boost, and Buck-Boost Converter Circuit overview, Buck Converter - Components, Buck Converter - circuit, Buck Converter - Analysis, Buck Converter, Boost Converter - Components, Boost Converter - Circuit, Boost Converter - Analysis, Boost Converter – Analysis, Buck-Boost Converter – Components, Buck-Boost Converter – Circuit, Buck-Boost Converter – Analysis, Push-Pull Converter: Half Bridge and Full Bridge operation, AC choppers: Construction, Working and types.

Unit-3 - Converters — **9 Hour**

Rectifiers: Characteristics and Circuit Configuration, Full Bridge Diode AC-DC Rectifier, Three-Phase Full-Bridge Diode Rectifier -Circuit Configuration, Three- Phase Full-Bridge Diode Rectifier – Analysis, Three-Phase Full-Bridge Diode Rectifier – Waveforms, Design of Dynamic Breaking Unit, Calculation of DC-Link Power, Three-Phase Full-Bridge. Thermistor AC-DC Rectifier-Circuit Configuration, Three-Phase Full-Bridge Thermistor AC-DC Rectifier-Analysis, Three-Phase Full-Bridge Thermistor AC-DC Rectifier-Waveforms, Topology and Operation Modes, 2 pulse and 6 pulse: Construction, Principle of Operation and Characteristics - Fire Angle Control Scheme, Ripple Inverters: Types of Inverters overview, Voltage Source Inverters: 120 and 180 degree mode of operation, Current Source inverters, Current Source inverters applications, Control Techniques –PWM generation and types, Harmonics , Current control techniques – Hysteresis Current Control Filter circuits, Multilevel inverters

Unit-4 - Automotive Motor Drives	***9 Hour***
Drive module architecture, DC motor drives: DC motor- Construction, Working Principle and types, Speed control techniques, converter fed operation, Introduction to brushless motor drive. DC motor drives-Types, Torque Production in Brushed DC-Motor Drives, Series operation connected DC motor drives, Induction Motor Drives: Induction motor- Construction, Working Principle and types, Speed control techniques, inverter fed operation, Introduction to permanent magnet motor drive, Induction Motor Drives., Induction motor Variable Speed Drive operating modes, Torque and speed control of Induction - Motor Drives, Fundamentals of Scalar and vector control for induction motor, Types of scalar control for induction motors, Vector control for induction motors, Types of vector control for induction motors, Induction motor drives for Electric Vehicles, Configurations Drive module for Electric vehicles.	
Unit-5 - Power Electronics Interface for Electric Vehicles	***9 Hour***
Schematic diagram of the battery electric vehicles, Power distribution, Power Management Control Strategy, Back-to-Back power converters, Calculation of DC-Link Power, Design of heat sink, G2V and V2G operation in EV, Power Quality Improvement, Automotive standards	

Learning Resources		
	1. *Ali_Emadi" Handbook of automotive power electronics and motor drives",3rd Edition, 2014* 2. *Ned Mohan, T.M.Undeland, W.P.Robbins," Power Electronics: Converters, applications and design", John wiley and Sons, 3rd Edition, 2006.*	3. *Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, 4th Edition, New Delhi, 2013*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Jegan Amirthalingam, Associate Director, Skill-*	1. *Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	1. *Dr.C.Carunaiselvane, SRMIST* 2. *Dr.T.Praveenkumar, SRMIST*

Course Code	21AUE414J	Course Name	MODELLING AND CONTROL OF ELECTRIC AND HYBRID VEHICLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes / Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	state and classify the electric and hybrid power train technologies
CLR-2:	investigate and interpret the performance characteristics of EV / HEV power train components
CLR-3:	classify and test the various EV / HEV energy storage technologies
CLR-4:	develop and relate the various Energy management control techniques for EV and HEV vehicles
CLR-5:	formulate and implement the Vehicle Dynamics Control Systems for EV and HEV vehicles

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	compare and operate the different electric and hybrid vehicle power train configuration	3	2	2	-	1	-	-	-	-	-	-	-	3	-	-
CO-2:	demonstrate and design the EV / HEV power train model and its components	3	3	3	-	2	-	-	-	-	-	-	-	3	-	-
CO-3:	identify and examine the storage batteries, fuel cells and ultra-capacitors used in vehicles	3	2	2	-	1	-	-	-	-	-	-	-	3	-	-
CO-4:	construct and solve the EV / HEV power and energy management systems	3	3	3	-	1	-	-	-	-	-	-	-	3	-	-
CO-5:	design the driver, vehicle, environmental model of EV/HEV dynamics control system	3	3	3	-	2	-	-	-	-	-	-	-	3	-	-

Unit-1 - Introduction to Electric Vehicles ***12 Hour***

Introduction to Electric Vehicles, Energy storage for EV, EV Configuration, Hybrid Electric Vehicles- Degree of Hybridization, Battery Electric Vehicles (BEV's) vs. Fuel Cell Electric vehicle (FCEV)technologies, Case Study on Tesla and Toyota Mirai

Practice*:*

1 Introduction Lab 2 Introduction to Virtual Instrumentation and Rapid control prototyping hardwar 3 Power/Energy Management System

Unit-2 - Electric and Hybrid Power Train Technologies ***12 Hour***

Selection of Motors: Criteria, Electric Motor Performance characteristics–Power-Torque characteristics, DC Motors Vs. AC Motors, Steady state Performance analysis, Advantage of BLDC motors, Battery Performance Characteristics- Battery Terminologies (OCP, SOC, DOD, Energy Density, Power density, Inverters and Motor drives, Regenerative Braking Characteristics

Practice:

4 Data acquisition using data loggers and virtual instrumentation hardware, 5 Interfacing Analog input, Signal conditioning using control hardware: 6 Control of actuators with Rapid control prototyping hardware

Unit-3 - Modelling and Characteristics of EV/HEV Power Train Components ***12 Hour***

Architecture of EV system, Electro chemical reactions, Battery technologies – Basic principle and Modelling of Lead acid battery and Lithium based Ultra- capacitors –Basic principle and Modelling, Fuel cells: Basic principle and Modelling

Practice:

7 Testing and validation of Electric Vehicle Battery, 8 Testing and Validation of Electric Motor for power assisted Steering system, 9 Speed control for Electric Vehicle motors

Unit-4 - Energy Storage	***12 Hour***
Energy management controllers, Battery Management system (BMS) for EV and HEV, Rule based Control Strategies for HEV and PHEV –Deterministic Rule- based, Fuzzy rule-based control strategies, Optimization based Control Strategies –Global Energy Management Optimization, Real-time Energy Management Optimization ***Practice****:* *10 Direction control of Electric Vehicle moto, 11 Electronic differential Design for Electric Vehicles, 12 Revision*	
Unit-5 - Energy Management Systems for EV and HEV	***12 Hour***
Fundamentals of Vehicle Dynamics Control (VDC) Systems –Driver Model, Fundamentals of Vehicle Dynamics Control (VDC) Systems –Environment Model, Working principle of VDC Systems, VDC System Overview, VDC implementation on Electric and Hybrid Vehicles-structure of the control system, Control system Design and simulation study, ***Practice:*** *13 Revision Lab, 14 Lab Model Examination, 15 Evaluation & Discussion*	

Learning Resources	1. *Amir Khajepour, M. Saber Fallah, AvestaGoodarzi-"Electric and Hybrid Vehicles Technologies, Modeling and Control - A MechatronicApproach" Wiley Publication,1st edition, 2014* 2. *Iqbal Husain, "Electric and Hybrid vehicles Design Fundamentals",CRC Press, 2nd edition, 2013*	3. *James Larminie, John Lowry, "Electric vehicle technology Explained", WileyPublication, 2nd edition, 2012* 4. *Ali Emadi, MehrdadEhsani, John M. Muller,"Vehicular Electric PowerSystems" Marcel Dekker, Inc., 2004*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	25%	*25%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	30%	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Jegan Amirthalingam, Associate Director, Skill-Lync*	1. *Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	1. *Dr.Arunkumar Jayakumar, SRMIST*
		2. *Dr.T.Praveenkumar, SRMIST*

Course Code	21AUE417T	Course Name	MACHINE LEARNING APPROACH FOR AUTOMOTVE APPLICATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basic concept of condition monitoring and Machine learning algorithm*
CLR-2:	*understand the different types of sensor signals and data acquisition system*
CLR-3:	*interpret and relate the different signal processing techniques*
CLR-4:	*compare and contrast the classification and regression models*
CLR-5:	*understand the implementation of condition monitoring techniques for automotive application*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*list and recognize the various machine techniques and condition monitoring techniques*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-2:	*identify and Estimate Parameters of signals using different sensors*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*identify and use various signal processing techniques*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*relate and use the various classification and regression models*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*investigation of condition monitoring for automotive application*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Condition Monitoring ***9 Hour***

Introduction to Machine Learning, Introduction to Condition Monitoring, Types of Machine Learning Techniques, Supervised, Unsupervised And Reinforcement Learning, Machinery Failures, Basic Maintenance Strategies, Factors Influencing Maintenance, Strategies, Factors Influencing Maintenance Strategies, Machine Condition Monitoring, Machine Condition Monitoring, Condition Based Maintenance Activity, Condition Based Maintenance Activity, Transducer Selection and Location, Transducer Selection and Location, PC Interfacing and Virtual Instrumentation, PC Interfacing and Virtual Instrumentation, Data Driven Approach in Machine Learning, Model Driven Approach in Machine Learning

Unit-2 - Sensing and Instrumentation ***9 Hour***

Types of Sensors in Condition Monitoring and its Application, Types of Sensors in Condition Monitoring and its Application, Different Types of Vibration Sensors, Working Principle of Piezoelectric Type Transducer, Different Types of Sound Sensors, Working Principle of Free Field Array Microphone, Basic Principle of Acoustic Emission (AE), Signals, Working Principle of AE Sensors, Types of Temperature Sensors and its Working Principle, Types of Ultrasonic Sensors and its Working Principle, Different Types of Infra-Red Sensors, Working Principles of IR Sensor and its Key Application, Oil Analysis, Thermography, Motor Current Analysis, Motor Current Analysis, Data Acquisition System (DAQ), Signal Conditioning

Unit-3 - Signal Processing ***9 Hour***

Basic Signal and Systems Concepts, Basic Signal and Systems Concepts, Time Domain Analysis, Time Domain Analysis, Frequency Domain Analysis, Frequency Domain Analysis, Time-Frequency Analysis, Time-Frequency Analysis, Wavelets Analysis, Wavelet Packets, Vibration Signatures of Faults in Rotating Machines, Vibration Signatures of Faults in Rotating Machines, Vibration Signatures of Faults in Reciprocating Machines, Vibration Signatures of Faults in Reciprocating Machines, Detection and Diagnosis of Faults, Detection and Diagnosis of Faults, Classification and Regression, Classification and Regression

Unit-4 - Pattern Recognition ***9 Hour***

Feature Extraction Methods, Feature Selection Methods, Feature Reduction using PCA - Discriminant Functions, Feature Reduction using PCA - Decision Boundaries, Feature Reduction using Decision Tree, Feature Reduction using Decision Tree, Classification using Maximum Likelihood, and Nearest Neighbor, Bayesian Theory, Neural Networks, Neural Networks, Fuzzy Logic, Fuzzy Logic, Support Vector Machines (SVM), Proximal Support Vector Machines (PSVM), Regression- Linear, Regression- Linear, Regression- Polynomial, Regression- Polynomial

Unit-5 - Automotive Applications	***9 Hour***
Application and Case Studies of Bearings, Application and Case Studies of Bearings, Case Study of Gearbox, Case Study of Gearbox, Case Study of Engines, Case Study of Engines, Structural Health Monitoring, Structural Health Monitoring, Machine Tool Condition Monitoring, Machine Tool Condition Monitoring, Machine Learning Vs Deep Learning, Machine Learning Vs Deep Learning, Machine Learning Vs Artificial Intelligence, Machine Learning Vs Artificial Intelligence, Machine Learning Applications Across Industries, Machine Learning Applications Across Industries, Tutorial, Tutorial	

Learning Resources		
	1. *Balageas D., Fritzen C P. and Guemes A. - 'Structural Health Monitoring' - Published by ISTE Ltd., USA – 2006* 2. *Clarence de Silva - 'Vibration and Shock Handbook'- CRC Taylor & Francis – 2005* 3. *Collacot Mechanical Fault Diagnosis and Condition Monitoring'- Chapman - Hall – 1987* 4. *Davies - 'Handbook of Condition Monitoring - Techniques and Methodology' – Springer -1998*	5. *Norton M. and Karczub D. – 'Fundamentals of Noise and Vibration Analysis for Engineers'– Cambridge University Press - 2003 - 2nd Edition* 6. *Duda R.O., Peter Hart E.,and Stork D. E. -Pattern Classification' -Wiley India -2007 – 2nd Edition.* 7. *Strang G. and Nguyen T. - 'Wavelets and Filter Banks' - Wellesley-Cambridge Press -1996*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Jegan Amirthalingam, Technical Specialist , Skill-lync jegan.a@skill-lync.com*	1. *Dr.S.Jeevanandan, Professor, Department of EEE, Pondicherry Technological University.*	1. *Dr. T. Praveenkumar, SRMIST*
2. *Mr.Govardhana Giri, Director, Atalon Product Center Pvt, Ltd. giri@atalon.co*	2. *Dr.Dheeraj K Khatod, Associate Professor, Dept. of EE, IITR*	2. *Dr.C.Carunaiselvane, SRMIST*

Course Code	21AUE372T	Course Name	DESIGN APPROACHES IN ELECTRIC VEHICLETECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*know about the working principle of electric vehicles*
CLR-2:	*identify the construction and working principle of various motors used in electric vehicles*
CLR-3:	*analyze the different control strategies used in electric motors for electric vehicles*
CLR-4:	*evaluate the different types and working principle of hybrid vehicles*
CLR-5:	*interpret the various types and working principle of batteries & fuel cells*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe about working principle of electric vehicles*	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-2:	*explain the construction and working principle of various motors used in electric vehicles*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*compare and analyze the different control strategies used in electric motors for electric vehicles*	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-4:	*describe the different types and working principle of hybrid vehicles*	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-5:	*illustrate the various types and working principle of batteries & fuel cells*	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Electric Vehicles ***9 Hour***

Electric Vehicle Need Types Cost and Emissions Cost and Emissions – End of life-Electric Vehicle Technology End of life-Electric Vehicle Technologylayouts- cables- components Controls. Batteries – overview and its types. Battery plug-in and life Ultra-capacitor- Charging – Methods and Standards. Alternate charging sources Wireless & Solar Introduction of electric vehicles Safety

Unit-2 - Electric Vehicle Motors ***9 Hour***

Motors (DC- Induction- BLDC) Types- Principle- Construction- Control, Electric Drive Trains (EDT), Series HEDT (Electrical Coupling), Power Rating Design, Peak Power Source (PPS), Parallel HEDT (Mechanical Coupling), Torque Coupling and Speed Coupling. Switched Reluctance Motors (SRM) Drives, Basic structure- Drive Convertor- Design. Testing of Motors/Generators, Selection of Motors under variable parameters

Unit-3 - Electronics and Sensor-Less Control in EV ***9 Hour***

Basic Electronics devices, Diodes- Thyristors, BJTs- MOSFETs- IGBTs- Convertors- Inverters, Safety – Risks and Guidance, Precautions- High Voltage safety Hazard management. Sensors - Autonomous EV cars, Self-Drive Cars, Hacking; Sensor less, Control methods- Phase Flux Linkage-Based Method- Phase Inductance, Mutually Induced Voltage-Matching of Battery and Engine, Motor and Wheels, Synchronizing

Unit-4 - Hybrid Vehicles ***9 Hour***

Hybrid Electric vehicles, Classification, Layout, operation modes, Architecture, Propulsion systems and components, Regenerative Braking, Regenerative Braking Economy, Economy, Vibration and Noise reduction, Vibration and Noise reduction, Hybrid Electric Vehicles System, Hybrid Electric Vehicles System, Analysis and its Types- Controls.

Unit-5 - Batteries and Fuel Cells for EVs & HEVs ***9 Hour***

Introduction Basics Terminologies used for Energy Storage, Oxidation & Reduction reaction, Cell construction, types, advantages & disadvantages, and working, principles of different battery chemistries used for EVs: Lead Acid Battery, Nickel batteries, Sodium batteries, Lithium batteries, Advancement in Li-ion batteries, Battery Management System, Battery Sizing for EVs & HEVs. Fuel Cells, Lifetime cost of Fuel cell Vehicle

Learning Resources	1. *Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. M. (2018). Modern electric, hybrid electric, and fuel cell vehicles. CRC press.* 2. *Larminie, J., & Lowry, J. (2012). Electric vehicle technology explained. John Wiley & Sons.* 3. *Husain, I. (2021). Electric and hybrid vehicles: design fundamentals. CRC press.*	4. *Liu, W. (2017). Hybrid electric vehicle system modeling and control. John Wiley & Sons.* 5. *Hayes, J. G., & Goodarzi, G. A. (2018). Electric powertrain: energy systems, power electronics and drives for hybrid, electric and fuel cell vehicles.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Ajeet Babu, Manager, ARAI*	1. *Mr. Shirish Mane*	1. *Dr. Y.K. Bhateshvar, ARAI*
2. *Mr. Rakesh Mulik, DGM, ARAI*	2. *Dr. Deepak Watvisave*	2. *Dr. S.A. Patil, ARAI*

Course Code	21AUE373T	Course Name	ENGINE DESIGN AND DEVELOPMENT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*define the nomenclature and parts of automotive engines*
CLR-2:	*know various aspects of automotive engine design*
CLR-3:	*identify the requirement, process and development of automotive engines*
CLR-4:	*evaluate the requirement of lubrication, cooling system and crankcase arrangement for automotive engines*
CLR-5:	*evaluate the requirement of fuel system and crank train arrangement for automotive engines*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge about the importance of automotive engines*	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-2:	*understand various aspects of automotive engine design*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*understand requirement, process and development of automotive engines*	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-4:	*demonstrate the requirement of lubrication, cooling system and crankcase arrangement for automotive engines*	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-5:	*demonstrate the requirement of fuel system and crank train arrangement for automotive engines*	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Engine Design and Operating Parameters	***9 Hour***
Need Requirements Engine Classifications Engine Classifications Engine Efficiency and Fuel Consumption Engine Efficiency and Fuel Consumption Brake Torque and Power Mean Effective Pressure, Air/Fuel and Fuel/Air Ratios, Performance Curves, Engine Specific Weight and Specific Volume Engine Downsizing Engine Packaging Engine Reliability and Durability	
Unit-2 - Engine Configuration and Balance	***9 Hour***
Engine Configuration based on Requirements Estimating Engine Displacement Estimating Engine Displacement Determining Number of Cylinders Determining Number of Cylinders Bore-to-Stroke Ratio Mean Piston Speed, Engine Noise Vibration and Harshness (NVH) Engine Forces and Couples Engine Balancing.	
Unit-3 - Engine Components Design	***9 Hour***
Engine Cylinder Block Engine Cylinder Block Features Deck Height Cylinder Bore Spacing Integral Cylinder Liner Wet Cylinder Liner Dry Cylinder Liner Cylinder Liner Positive Crankcase Loads and Sizing, Cylinder Head Layout Design, Intake Port Ventilation, Bearing Swirl and Tumble, Intake Port and Manifold Length Exhaust Port and Manifold Length, Piston Construction, Piston Design	
Unit-4 - Lubrication, Cooling and Crankcase System	***9 Hour***
Pump type, sump, size and location Lubrication circuit, Oil drain back and scavenging Crankcase ventilation, breathing Pump drive and location Cooling System Cooling System Pump capacity and temperature control Circuit design and analysis Flywheel sizing Accessory Systems Additional drives (power steering, hydraulic pump, air pumps) Alternator, starter and compressor (air, HVAC)	
Unit-5 - Fuel System, Crank train, Valve Train and Camshafts	***9 Hour***
Fuel system Injectors and spark plugs Combustion chamber design Combustion chamber design Gear train type and location Crankshaft sizing and proportions Bearings, Connecting rod size and type, journals, crank webs, torsional vibration & damper Camshaft and valve train Type of valve train, number Type of valve train, number Valve arrangement and location of camshafts Cam drive	

Learning Resources	1. *Hoag Kevin L., Vehicular Engine Design, Springer-Verlag, USA, 2006.* 2. *Engineering Know-How in Engine Design (Part 1 to 24), SAE, USA.*	3. *Applications and Developments in New Engine Design and Components, SAE, USA* 4. *Goetze A. G., Piston Rings Manual, Technischer Verlag Herbert Cram* 5. *"Bosch' Automotive Handbook", 8thEdition*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr S S.Ramdasi,*	1. *Dr. M. R. Nandgaonkar*	1. *Mr H J Gayen, ARAI*
2. *Mr N V Marathe*	2. *Dr. Sanjay Kumbhar*	2. *Mr Aatmesh Jain, ARAI*
		3. *Mr K Saravanan, ARAI*

Course Code	21AUE374T	Course Name	ENERGY MANAGEMENT AND STORAGE SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*know different types of energy storage system*
CLR-2:	*identify the battery characteristic & parameters*
CLR-3:	*compare different types of batteries*
CLR-4:	*evaluate the concepts of battery management system and design the battery pack*
CLR-5:	*evaluate the battery testing, disposal and recycling*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*discuss about the different types of energy storage system*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*describe about the battery characteristic & parameters*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*model different types of batteries*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*apply the concepts of battery management system and design the battery pack*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*explain about the battery testing, disposal and recycling*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Energy Storage System ***9 Hour***

Batteries: Introduction Lead Acid Battery Nickel based batteries, Sodium based batteries, Lithium based batteries Lithium based batteries – Li-ion & Li-poly,Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System.

Unit-2 - Battery Constructions ***9 Hour***

Cells and Batteries - conversion of chemical energy to electrical energy, Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters- Heat generation Battery design-Performance criteria for Electric vehicles batteries, Vehicle propulsion.

Unit-3 - Battery Modelling ***9 Hour***

General approach to modelling batteries Simulation model of a rechargeable Li-ion battery, Simulation model of a rechargeable NiCd battery, Parameterization of the NiCd battery model. Simulation examples

Unit-4 – Battery Pack and Battery Management System ***9 Hour***

Selection of battery for EVs & HEVs Traction Battery Pack design Requirement of Battery Monitoring Battery State of Charge Estimation methods battery State of Charge Estimation methods Battery Cell equalization problem, thermal control Protection interface, SOC Estimation, Energy & Power estimation Battery thermal management system, Battery Management System: Definition, Parts: Power module Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

Unit-5 - Battery Testing, Disposal and Recycling ***9 Hour***

Chemical & Structure material properties for cell safety and battery design Battery Testing, Limitations for transport & storage of cells and batteries Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, Leakage path, leakage rates. Ruptures: Mechanical stressand pressure tolerance of cells Safety vents, Explosions: Causes of battery exp.

Learning Resources	1. *G. Pistoia, J.P. Wiaux, S.P. Wolsky, "Used Battery Collection and Recycling", Elsevier, 2001. (ISBN: 0-444-50562-8)"* 2. *Guangjin Zhao, "Reuse and Recycling of Lithium-Ion Power* 3. *Batteries", John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9)* 4. *T R Crompton, "Battery Reference Book-3rd Edition", Newnes- Reed Educational and Professional Publishing Ltd., 2000.* 5. *Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", JohnWiley & Sons Ltd., 2016.*	6. *Chris Mi, Abul Masrur & David Wenzhong Gao, "Hybrid electric* 7. *Vehicle- Principles & Applications with Practical Properties", Wiley, 2011.* 8. *Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric Hybrid Electric and Fuel Cell Vehicles", Taylor & Francis Group, 2010.* 9. *James Larminie, John Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003.* 10. *Arno Kwade, Jan Diekmann, "Recycling of Lithium-Ion Batteries: The LithoRec Way", Springer, 2018. (ISBN: 978-3-319-70571-2)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr Rahul Bollini, Consultant*	1. *Dr Parag Jose, Assistant Professor, CHRIST (Deemed to be University)*	1. *Mr Punit Kongi, Assistant Faculty, ARAI*
2. *Miss Hemavathi , Scientist, CSRI*	2. *Mr Gowtham Sanjay, Assistant Professor, CHRIST (Deemed to be University)*	2. *Dr. Sanjay A. Patil, General Manager, ARAI*

Course Code	21AUE375T	Course Name	ALTERNATE ENERGY FOR MOBILITY APPLICATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*define the physio-chemical characteristic of fuels in IC engine*
CLR-2:	*categories the techniques in production, storage and handling techniques of a fuel*
CLR-3:	*identify the features and methods adopted for the of alternative fuels in SI engines*
CLR-4:	*Identify the features and methods adopted for the of alternative fuels in CI engines*
CLR-5:	*compare the technical features of EV-HEV and Fuel Cell for automotive applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the potential and feasibility to use fuel in IC Engines through its physio-chemical characteristics*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*understand various production, storage and handling techniques of a fuel*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*explain the concept-method, modifications and various features related to use of alternative fuels in SI engines*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*explain the concept-method, modifications and various features related to use of alternative fuels in CI engines*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*illustrate the technical features of EV-HEV and Fuel Cell for automotive applications*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction	***9 Hour***
Status of petroleum reserves, Economics; Need for alternative fuels, Alternative Fuel Requirements; Advantage & Disadvantages of different alternative fuel;Review of fuel properties. Alternative Fuel Adaptability Techniques. Comparison of density, Fuel consumption and emissions, Fuel import/export statistics, Government of India Policies, National Biofuel Policy	
Unit-2 - Alcohol Fuel	***9 Hour***
General properties, Alcohol Production process, Compatibility as a fuel, Properties as engine fuel, Alcohols and gasoline blends, Performance and emission analysis in SI engine, Feasibility study of alcohol in CI engines, Performance and emission analysis in CI engines, Modifications required to use in engines.E85, ED95, DME, DEE fuels and their characteristics, Flex fuel vehicle, reformed alcohol.	
Unit-3 - Gaseous Fuel: Natural Gas, LPG, Hydrogen and Biogas	***9 Hour***
Introduction to CNG, LNG and LPG fuel, Availability of CNG, LPG, Properties of natural gas, Modification required to use inengines, Performance and emission, Characteristics of CNG & LPG in SI & CI engines, Biogas, Producer Gas. LNG as a power source to Heavy Duty Vehicles, CNG Gas cylinder, Kit testing methods, Hydrogen: Properties, Production methods, Storage methods – challenges associated, Safety Aspects Use in SI and CI engines; Engine/vehicle level modifications required Performance and emissions; On-board hydrogen generation methods; well to wheel life cycle analysis.	
Unit-4 - Biofuels	***9 Hour***
Generation of Biofuels, Composition and properties, Various vegetable oils for engines, esterification, Biodiesel Production Process, Optimization in production process, Performance & emissions characteristics in engines, Biodiesel standards, Issuesrelated to biofuels in engines, Super-critical alcoholic's, Gas to liquid, process; F-T Process; Synthetic Fuel, Plastic Fuel.	
Unit-5 - Electric, Hybrid and Fuel Cell	***9 Hour***
Layout of an electric vehicle, Advantage and limitations, System components, Electronic control system, Hybrid Vehicle, Various Architecture of HEVs,Fuel cells - Types, working, Fuel cells: Advantages, and Disadvantages , Performance Parameters, Losses associated in fuel cells, Synthetic fuel – Gas to liquid process, Fisher Tropic process, DME & DEE, Plastic fuel.	

Learning Resources	1. *Thipse S. S, (2010), Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House.* 2. *Michael F. Hordeski, (2013), Alternative Fuels: The Future of Hydrogen, the Fairmont Press, Inc.* 3. *Maheswar Dayal - "Energy today & tomorrow"- I & B Horish India - 2012.* 4. *Ganesan V., (2012), Internal Combustion Engines, McGraw-Hill Education India Pvt. Ltd*	5. *Richard.L.Bechfold – Alternative Fuels Guide Book - SAEInternational Warrendale - 1997.* 6. *Nagpal - "Power Plant Engineering" - Khanna Publishers, 16thedition, 2015.* 7. *Alcohols as motor fuels progress in technology -SeriesNo.19 -SAE Publication USE - 1980.* 8. *SAE paper nos. 840367, 841333, 841334, 841156, Transactions,SAE, USA.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr S S Thipse, EDL, ARAI*	1. *Mr Shirish Mane, RIT*	1. *Mr Aatmesh Jain, Deputy Manager, ARAI*
2. *Mr Nagendra Chintakula, FEV*	2. *Dr K R Patil, MMCOE*	2. *Mr H J Gayen, GM, ARAI*

Course Code	21AUE376T	Course Name	INTELLIGENT TRANSPORT SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	familiarize with the concepts of digital map database
CLR-2:	know the usage of neural network for intelligent vehicle system
CLR-3:	analyze the concepts of sensors and communications protocols
CLR-4:	apply the concepts of ADAS for vehicle systems
CLR-5:	compare the challenges for vehicle Autonomy for Indian scenario

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	describe the digital map database	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-2:	analyze use of neural network for intelligent vehicle system	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	understand use of different Sensor & Its applicability for IVS	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-4:	build smaller / simpler ADAS system	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-5:	describe challenges for vehicle Autonomy for Indian scenario	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Basics of Intelligence	**9 Hour**
Definition of intelligence, systems blocks for data collection (data gathering) Need Definition of intelligence, systems blocks for data collection (data gathering) data pruning/cleaning and sanity checks (levels and understanding), data pruning/cleaning and sanity checks (levels and understanding) use or adaptation beyond data, use or adaptation beyond data, data and its properties statistical measures and tests, statistical measures and tests, statisticalmeasures and tests automotive applications.	
Unit-2 - Neural Network and its Implementation	**9 Hour**
Basics of Neural network, multiple hidden layers, Convolution, open source framework (such as Tensor flow and Auto ware), programming framework, programming framework	
Unit-3 - Sensors and Communication	**9 Hour**
LiDAR, RADAR, Camera, specifications and utilization, CAN OBD, communication - V2V, communication V2V, VI, V2X, Internet of Cars, communication V2V, VI, V2X, Internet of Cars.	
Unit-4 - ADAS Applications	**9 Hour**
Simultaneous localization and motion, path planning, ambience awareness, driver drowsiness and intent detection, machinelearning, algorithms for automotive applications, machine learning algorithms for automotive applications.	
Unit-5 - What Next in Automotive Intelligence	**9 Hour**
Prognostics and diagnostics of moving vehicle, vehicle health monitoring and status checks, last mile mobility solutions, trends and future of automotiveintelligence (dialog system, speaker awareness), (Auto cyber security challenges for implementation in Vehicle, Auto cyber security challenges for implementation in Vehicle, Auto cyber security challenges for implementation in Vehicle.	

Learning Resources	1. *Lawrence D. Burns, Christopher Shulgan, "Autonomy: The Quest to Build the Driverless Car-And How It Will Reshape Our* 2. *Reports on Automotive Intelligence by various agencies such as McKinsey, Price water house Cooper (PwC),Standard chartered, IBM, NITI Aayog*	3. *Intelligent Transportation Systems from Good Practices to Standards By Paolo Pagano, Published by CRC Press, ISBN 9780367782825* 4. *Perspectives on Intelligent Transportation Systems (ITS) by Professor Joseph M. Sussman from MIT*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Ajeet Babu, Manager, ARAI*	1. *Mr. Shirish Mane*	1. *Dr. Y.K. Bhateshvar, ARAI*
2. *Mr. Rakesh Mulik, DGM, ARAI*	2. *Dr. Deepak Watvisave*	2. *Dr. S.A. Patil, ARAI*

Course Code	21AUE471T	Course Name	VEHICLE BODY AND CRASH WORTHINESS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Automobile Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	know the different vehicles layout, bodies and correlate with AIS053 standard requirements
CLR-2:	identify the vehicle body topology, and summarize vehicle body nomenclature
CLR-3:	evaluate structural elements, Diagnose vehicle crashworthinessrequirements
CLR-4:	compare the materials used in Automotive to meet the weight, safety requirement
CLR-5:	evaluate the Vehicle safety features for the modern vehicle systems

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	recognize & explain different vehicles layout, bodies and correlate with AIS 053 standard requirements	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-2:	construct a vehicle body topology, and summarize vehicle body nomenclature	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	analyze structural elements, Diagnose vehicle crashworthiness requirements	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-4:	demonstrate materials used in Automotive to meet the weight, safety requirement	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-5:	application of studied course work in understanding the Vehicle safety & future	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction **9 Hour**

Vehicle Layout, AIS 053 - Vehicle Types & Terminology, Vehicle Categories (L, M, N, C, A, T, O and G), Vehicle Layouts and Types (Car Body Construction), Body Functions, Fundamentals of Vehicle Crash and Calculations - Galileo's Principal of Inertia, Newton's First Law, Newton's Second Law – Momentum and Impulse, Acceleration Due to Gravity, Impact of Crash on A Human Body, Crashworthy

Unit-2 - Passenger Vehicle Body **9 Hour**

The Automobile Body, DMU - Digital Mock-Up, Aggregate Packaging Like Power Train, Suspension, Wheels and Human (At Least Driver), Description of the Automobile Body Types, Space Frame, Central Frame, Body-on-frame, Monocoque Body Configuration, Body Nomenclature, Vehicle Layout (Side-view, front-view, plan-view vehicle layout), Different types of Car Body Style, Body work - Body in White

Unit-3 - Monocoque Body Structure and Crashworthiness **9 Hour**

Categories of Structural Requirements, Locate and Retain Function with Example, Flow Down of Requirements From Vehicle-Level Functions, Overview of Classical Beam Behavior, Design of Automotive Beam Sections, Design For Durability (Road Load Data, Torsion, Bending Stiffness & Fatigue), and NVH; Design For Crashworthiness (Crashworthiness- Deceleration Curve, Square Wave, Injury Tolerance, Control Of Deceleration), Standardized Safety Test Conditions and Requirements, Introduction To Crash Safety, Crash Tests: Front Barrier, Side Impact, Rear Impact and Roof Crush.

Unit-4 - Vehicle Body Materials, Trim, and Mechanism **9 Hour**

Automotive Body Requirements, Automotive Body Structural Elements, Automotive Body Materials, Lightweight and High Strength Steel Alloys, Steels Used in Automotive Bodies (AHSS: DP Steel CP Steel, MART Steel, FB Steel, HF Steel, TRIP Steel, TWIP Steel, Hot Formed, Bake Hardened, IFHS, HSLA, Cmn, Plastic/Composite, Austenitic Grade, and Magnesium and Aluminum, Electric Vehicle Battery Pack Structure and Materials Plastics Used in Automotive, Materials Used in Electric Vehicles (Battery, Battery Pack, Motors). Manufacturing Processes and Joining / Assembly Methods. Manufacturing Processes and Joining / Assembly Methods.

Unit-5 - Vehicle Safety **9 Hour**

Automotive Safety, Road Safety – Five Pillars, Basic Concept of Vehicle Safety: Principles, Fail-Safe, Alternate Design, Human Error Control, Occupant Injury Prevention: Biokinetics, Technology & Regulations, Recent Advancements (Active and Passive Safety), (Active And Passive Safety), Future Vehicle Safety, NCAP Ratings, Future Vehicle Safety, NCAP Ratings

Learning Resources	1. *Donald E. Malen; "Fundamentals of Automobile Body Structure Design"; SAE International Publication 2019* 2. *Morello, Rossini, Pia and Tonoli; "The Automotive Body Vol I and II"; Springer Publication 2015* 3. *George A. Peters, Barbara J. Peters; "Automotive Vehicle Safety"; CRC Press (Taylor & Francis, London) 2016* 4. *Heinz Heisler, "Advanced Vehicle Technology", second edition, Butterworth – Heinemann, New York, 2002.*	5. *Mark Gonter, Ulrich W. Seiffert; Integrated Automotive Safety Handbook R-407; SAE International Julian Happian-Smith, an Introduction to Modern Vehicle Design, Butterworth- Heinemann.* 6. *K. Newton, W.Steeds and T.K.Garret, "The Motor Vehicle", 13th Edition, Butterworth Heinemann, India Automotive Hand book/ Robert Bosch, SAE, 2003.* 7. *Powloski. J., Vehicle Body Engineering, Business BooksLtd.* 8. *Priya Prasad, Jamel E. Belwafa; Crashworthiness andOccupant Protection, American Iron and Steel Institute, Southfield, Michigan Mark Gonter, Ulrich W. Seiffert* 9. *P. M. Heldt, "Automotive Chassis", Chilton Co., NewYork, 1982.* 10. *W.Steed, "Mechanics of Road Vehicles", IlliffeBooks Ltd., London.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Ajeet Babu, Manager, ARAI*	1. *Mr. Shirish Mane*	1. *Mr. Nilesh A Sakle,ARAI*
2. *Mr. Rakesh Mulik, DGM, ARAI*	2. *Dr. Deepak Watvisave*	2. *Mr. Punit Kongi, ARAI*

Course Code	21AUE472T	Course Name	NOISE VIBRATION AND HARSHNESS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand various sources of noise and vibration in automotiveapplications*
CLR-2:	*know working of noise & vibration measuring instruments*
CLR-3:	*apply the significance of acoustic materials and its application*
CLR-4:	*compare noise control techniques*
CLR-5:	*compare signal analysis techniques*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the various sources of noise and vibration in automotive applications*	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-2:	*infer working of noise & vibration measuring instruments*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*categories significance of acoustic materials and its application*	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-4:	*enumerate the methods in noise control techniques*	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-5:	*enumerate the signal analysis techniques*	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - NVH in the Automotive Industry	***9 Hour***
Sources of Noise and Vibration, Design Features, Common Problems, Pass-By Noise Requirements, Target Vehicles and Objective Targets, VehicleStructure Noise, Engine Noise, Transmission noise, and Exhaust noise.	
Unit-2 - Vibration Theory	***9 Hour***
Transient state response, Steady State Response, one degree of freedom system, Transient and steady state response of one degree of freedom system applied to vehicle systems, Transmissibility, Modes of Vibration	
Unit-3 - Basics of Sound	***9 Hour***
Sound Measurement, Human Sensitivity and Weighting Factors, Human Sensitivity and Weighting Factors, Combining Sound Sources, Acoustical Resonances, Properties of Acoustic Materials	
Unit-4 - Test Facilities and Instrumentation	***9 Hour***
Anechoic Rooms, Silent Room, Modal Analysis, Data Acquisition System, Sound Pressure Level Measurements, Microphone, Accelerometers, Sound Sources Impedance Tube, Transmission Loss Measurement, Sound Absorption Coefficient Measurement, etc. Transducers, Signal Conditioning	
Unit-5 - Signal Processing	***9 Hour***
Sampling, Aliasing and Resolution, Statistical Analysis, Frequency Analysis, Campbell's Plots, Cascade Diagrams, Coherence and Correlation Functions	

Learning Resources	1. *Matthew Harrison, "Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles", Elsevier, 2004* 2. *Noise and Vibration Control, Munjal, M.L. USA World Scientific Publishing Co.Pvt.Ltd., 2013* 3. *Noise and vibration control engineering - principles and applications Ver, Istvanl, USA John Wiley & Sons, 2006*	4. *Handbook of noise and vibration control Crocker, Malcolm J., Crocker, Malcolm J., USA John Wiley & sons, 2007* 5. *Vehicle noise and vibration refinement Wang, Xu, Wang, Xu, USA Woodland Publishing Limited,, 2010* 6. *Active control of noise and vibration, Hansen, Colin; Snyder, Scott New York CRC PRESS, 2013 Fundamentals of noise and vibration analysis for engineers, Norto*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr S S Ramdasi*	1. *Dr. M. R. Nandgaonkar*	1. *Mr Kiran Wani, ARAI*
2. *Mr N V Marathe*	2. *Dr. Sanjay Kumbhar*	2. *Mr Punit Kongi, ARAI*

Course Code	21AUE473T	Course Name	MOTOR DRIVES AND CONTROL SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*familiarize the fundamental concept of Electromagnetics*
CLR-2:	*familiarize the fundamental concept of control systems*
CLR-3:	*demonstrate the Operation and behavior of DC drives*
CLR-4:	*demonstrate the Operation and behavior of AC drives*
CLR-5:	*implementation of controllers for EV applications*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enumerate the concepts of Electromagnetics*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*enumerate the concepts of control systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*infer the Operation and behavior of DC drives*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*infer the Operation and behavior of AC drives*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*identify and Apply controllers for EV applications*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction	***9 Hour***
Magnetically coupled circuits, Review of basic concepts, Magnetizing inductance, Modelling linear magnetic circuits, Modelling nonlinear magnetic circuits, Electromechanical energy conversion, Concept of field energy, Examples: Simulation study using Multiphysics tool, Torque expression, Principle of energy flow, Principle of co-energy flow, Examples: Simulation study using Multiphysics tool	
Unit-2 - Concepts of Control Systems	***9 Hour***
Overview of Control system, Control system and examples, Mechanical translational system, Mechanical rotational systems, Transfer function basics, Transfer function of rotating machine, Electrical analogous of Mechanical translational systems, Block diagram representation of Drive systems, Signal flow graph representation of the systems, Numerical examples	
Unit-3 - DC Motor Drives	***9 Hour***
Introduction: DC traction motor, Principle of DC motor, Speed control of DC motor, Dynamics of D.C. motor drives, Basic features of an Electric Drive, Criteria for selection of drive components, Introduction: DC Chopper, Principle of operation: DC chopper, Chopper controlled drives, Control Techniques , Duty-ratio control, Current-limit control, Chopper circuit : four quadrant operation, Chopper fed drive: Applications, Examples: Simulation study using mathematical solver tool, duction: AC traction motor, Principle of AC motor, Speed control of AC motor, Variable voltage operation, Variable frequency operation, Constant flux operation, Torque-Slip characteristic	
Unit-4 - AC Motor Drives	***9 Hour***
Introduction: AC traction motor, Principle of AC motor, Speed control of AC motor, Variable voltage operation, Variable frequency operation, Constant flux operation, Torque-Slip characteristic, Implementation of V/f control, Slip compensation scheme, Vector control scheme, Inverter fed Closed loop control schemes, Dynamic and regenerative braking, Speed reversal, Examples: Simulation study using mathematical solver tool	
Unit-5 - EV System Layout and Design	***9 Hour***
Classifications of EV motors Unit 1, Transfer function for EV motors, Closed loop control: Current feedback, Closed loop control: Speed feedback, Armature voltage control, Field oriented control, Design of controllers: Fundamentals and calculations, Current controllers, Speed controllers, Examples: Simulation study using mathematical solver tool, Converter selection and characteristics	

Learning Resources	1. R. Krishnan, "Electric Motor Drives – Modelling,Analysis and Control", PHI. 2015 2. P.S. Bhimbra, "The Generalized Theory of Electrical Machines", Tata McGraw Hill, 2021. 3. C.V. Jones, "The unified Theory of ElectricalMachines", Butterworth, -London.1967	4. Gopal K.Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 1992. 5. I.J.Nagarath and M. Gopal, Control system Engineering,New Age International (P) Ltd, 2021. 6. A. Nagoor Kani, Control System, RBA Publications, 2017.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, TechnicalSpecialist , Skill-lyncjegan.a@skill- lync.com	1. Dr.S.Jeevanandan, Professor, Departmentof EEE, Pondicherry Technological University.	1. Dr. Carunaiselvane C, SRMIST
2. Mr.Govardhana Giri, Director, AtalonProduct Center Pvt, Ltd. giri@atalon.co	2. Dr.Dheeraj K Khatod, Associate Professor,Dept. of EE, IITR	

Course Code	21AUE474T	Course Name	AUTOMOTIVE EMBEDDED SYSTEMS AND COMMUNICATION PROTOCOL	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*familiarize with the principles and applications of embedded systems*
CLR-2:	*familiarize with the architecture and peripherals interfacing*
CLR-3:	*identify the usage of programming in embedded system*
CLR-4:	*infer and implement the development embedded softwareconfiguration and applications*
CLR-5:	*implementation of the automotive communication protocols and Sub systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*perform the basic operations of automotive embedded systems*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*learn using the peripherals used in automotive controllers*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply Programming techniques to automotive embedded systems*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*perform the basic operations on real time operating systems*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*demonstrate the communication protocols in automotive systems*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Embedded Systems ***9 Hour***

Introduction to embedded systems, Characteristics of Embedded systems, Build Process for embedded systems overview, Challenges in Embedded SystemDesign, Design Process: Requirements, Specifications, Design Process: Architecture Design , Designing of Components System Integration (Battery & Subsystems), Embedded System Architecture, Instruction Set Architecture CISC and RISC instruction set architecture, Basic Embedded Processor/Microcontroller Architecture, CISC Examples, Motorola (68HC11) Example, 8051, RISC Example, ARM,Co-processors and Hardware Accelerators, DSP Processors, Processor Performance Enhancement, Harvard Architecture, PIC, Memory System Architecture, Caches, Virtual Memory, Pipelining, Super-scalar Execution, Memory Management Unit and Address Translation, I/0 Sub-system, Busy-wait I/0, DMA, Interrupt driven I/0

Unit-2 - Embedded System Architecture ***9 Hour***

Embedded Systems Architecture Introduction, Memory Organization, Memory Devices and their Characteristics RAM, ROM, UVROM, EEPROM, Flash Memory, DRAM, Memory Organization Tutorial, /O Devices, Timers and Counters, Watchdog Timers, Interrupt Controllers , DMA Controllers, A/D and D/A Converters, I/O Device Interfacing, Keyboard, Displays, Serial Port, Converters, Interfacing Demo Component Interfacing, Memory Management and addressing, Interfacing Protocols: GPIB, FIREWIRE, USB, IRDA, Designing with Processors: System Architecture, Hardware Design, FPGA Based Design, Implementation: Development Environment, Debugging Techniques, Manufacturing and Testing, Design Examples: Data Compressor, Alarm Clock

Unit-3 - Embedded System Programming ***9 Hour***

Programming Embedded Systems, Program Design, Design Patterns for Embedded Systems, Models of Program: Control and Data flow Graph, Programming Languages: Desired Language Characteristics, Introduction to Object Oriented Programming, Data Typing Overloading and Polymorphism, Control in embedded systems, Multi-tasking and Task Scheduling, Timing Specifications, Run-time Exception handling, Use of High Level Languages, C for Programming embedded systems, Object Oriented Programming for Embedded, High level software for Embedded Systems - Overview, Programming and Run-time Environment, Compiling, Assembling, Linking, Debugging, Programming and execution – Demo, Basic Compilation Techniques, Analysis and Optimization of Execution Time, Analysis and Optimization of Energy and Power, Analysis and Optimization of Program Size, Program Validation and Testing

Unit-4 - Operating System	***9 Hour***
Basic Features of an Operating System, Kernel Features: Real-time Kernels, Polled Loops System, Co-routines, Interrupt- driven System, Multi-rate System, Processes and Threads, Context Switching, Cooperative Multi-tasking, Pre-emptive Multi- tasking, Scheduling types: Rate-Monotonic, Earliest-Deadline First Scheduling, Task Assignment, Fault-Tolerant Scheduling, Inter-process Communication: Signals, Shared Memory Communication, Message-Based Communication, Process Stack Management, Dynamic Allocation, Real-time Memory Management, I/O: Synchronous and Asynchronous I/O, Interrupt Handling, Device Drivers, Real-time Transactions and Files, Example Real-time OS, RTOS Classification - Hard Real-time and Soft Real time, RT-Linux, Psos, Evaluating and Optimizing Operating System Performance, Response-time Calculation Interrupt latency, Time-loading Memory Loading, Power Optimization Strategies for Processes	
Unit-5 - Processors for Automotive Application	***9 Hour***
Introduction to Automotive grade processors, Automotive grade processors ex: Renesas, Quorivva , Automotive grade processors : NXP, Infineon, Architectural attributes of Automotive grade processors, On-chip Peripherals for ECU overview, Special On-chip Peripherals for Body and chassis control applications, On-chip Peripherals for Electric/hybrid Power train control, On-chip Peripherals for battery System, On-chip Peripherals case study, Overview of Automotive communication protocols : CAN, LIN, Automotive communication protocols : Flex Ray, MOST, Automotive communication protocols : Ethernet,D2B and DSI, Automotive communication protocols - case study, Real-time operating system Demo– for task scheduling activities, RTOS types - Hard Real-time and Soft Real time, RTOS Case Study with real time hardware, Embedded Systems Case Studies – Motor Control System, Case Study – Battery Monitoring System	

Learning Resources	1. *Miroslaw Staron, "Automotive Software Architectures:An Introduction", Springer, 2017. (ISBN: 978-3-319-58609-0)* 2. *Nicolas Navet and Francoise Simonot-Lion, "Automotive Embedded Systems Handbook", CRC Press, 2009. (ISBN: 978-0-8493-8026-6)* 3. *Muhammad Ali Mazidi, SarmadNaimi, SepehrNaimi "AVR Microcontroller and Embedded Systems using Assembly and C"Pearson Custom Electronics Technology, 2011* 4. *DataSheets of Kinetis 32-bit MCU based on ARM,InfineonXCxx series and Multicore Aurix Architecture*	5. *Ronald K. Jurgen, "Distributed Automotive Embedded Systems", SAE International, 2007. (ISBN: 978-0-7680-1966-7).* 6. *Gilbert Held "Inter and Intra Vehicle Communications: Auerbach Publications,2008* 7. *Tom Weather Jr. &Cland c. Ilunter, "Automotive computers and control system" Prentice Hall Inc., New Jersey*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Jegan Amirthalingam, TechnicalSpecialist , Skill-lync jegan.a@skill-lync.com*	1. *Dr.S.Jeevanandan, Professor, Department of EEE, Pondicherry Technological University.*	1. *Dr. T. Praveenkumar, SRMIST*
2. *Mr.Govardhana Giri, Director, Atalon Product Center Pvt, Ltd. giri@atalon.co*	2. *Dr.Dheeraj K Khatod, Associate Professor, Dept. ofEE, IITR*	

Course Code	21AUE475T	Course Name	AUTONOMOUS VEHICLE SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*familiarize the fundamental concept of Autonomous Driving*
CLR-2:	*familiarize the fundamental concept of Autonomous VehicleLocalization*
CLR-3:	*demonstrate the Operation and behavior of Perception and AI in Autonomous Driving*
CLR-4:	*demonstrate the Planning Operation and Control behavior of Autonomous Systems*
CLR-5:	*implementation of Client Systems, Cloud for EV Autonomous Systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enumerate the concepts of Autonomous Driving*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*enumerate the concepts of Localization*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*infer the Perception Operation and AI*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*infer the Planning Operation and Control of Autonomous Systems*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*identify and Apply Client Systems and Cloud for Autonomous Systems*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction — ***9 Hour***

Autonomous Driving Technologies Overview, Sensing, Perception, Object Recognition and Tracking, Autonomous Driving Client System, RobotOperating System, Hardware Platform, Autonomous Driving Cloud Platform, Simulation Methods, Map Types and Generation Methods, Deep Learning for Autonomous systems, Model Training, Methods,

Unit-2 - Localization Techniques — ***9 Hour***

Localization with GNSS, GNSS Error Analysis, Satellite-based Augmentation, Real-Time GPS, Positioning and Integration, Localization with LiDAR, High-Definition Map Generation, Visual Odometry - Stereo, Visual Inertial Odometry, Dead Reckoning and Wheel Odometry, Wheel Odometry and Errors, Reduction of Wheel Odometry Errors, Sensor Fusion, Examples on Localization

Unit-3 - Sensing Concepts — ***9 Hour***

Introduction: Perception, Datasets and Acquisition Methods, Segmentation and Classification, Stereo Vision Flow, Optical Flow, and Scene Flow, Tracking Methods , Introduction: Deep Learning, Convolutional Neural Networks, Object Detection, Semantic Segmentation, Traffic Prediction, Behavior Prediction as Classification, Vehicle Trajectory Generation, Lane Level Routing, Routing Graphs and Algorithms, Examples: Perception, Prediction and Routing

Unit-4 - Approaches to Sensors Assist — ***9 Hour***

Behavioral Decisions, Scenario-based Divide and Conquer Approach, Motion Planning, Vehicle Model, Road Model, and Coordination System, Path Planning and Speed Planning, Longitudinal and Lateral Planning, Feedback Control, Bicycle Model, PID Control Example, Reinforcement Learning, Reinforcement Learning Actor-Critic Methods, Reinforcement Learning on Behavioral Decision,, Reinforcement Learning on Planning and Control, Implementation of Reinforcement Learning, Examples: Planning and Control

Unit-5 - Functionality of Operating Systems — ***9 Hour***

Operating System for Autonomous Driving, Robot Operating System ROS Overview, System Reliability, Performance, Security, Computing Platform Implementation, Computer Architecture Design Exploration, Distributed Computing Framework, Heterogeneous Computing, Simulation, Connecting Spark and ROS, HD Map generation, Map Generation in the Cloud, Examples: Client Systems, Examples: Cloud Platforms

Learning Resources	1. *Shaoshan Liu, "Electric Motor Drives – CreatingAutonomous Vehicle Systems", Morgan & ClaypoolPublishers. 2018* 2. *Hong Cheng, "Autonomous Intelligent Vehicles Theory, Algorithms, and Implementation", Springer London DordrechtHeidelberg New York, 2011.* 3. *Markus Maurer, J. Christian Gerdes, Barbara Lenz, HermannWinner, Autonomous Driving Technical, Legal and Social Aspects", Springer-Verlag GmbH Berlin Heidelberg, 2015.*	4. *Syed Faraz Hasan, Nazmul Siddique and Shyam Chakraborty, "Intelligent Transportation Systems-802.11-based Vehicular Communications" SpringerInternational Publishing AG, 2018.* 5. *Gilbert Held, "Inter- and Intra-Vehicle Communications", Auerbach Publications, 2008.A. Nagoor Kani, Control System, RBA Publications, 2017.* 6. *Luca Delgrossi, Tao Zhang, "Vehicle Safety Communications- Protocols, Security, and Privacy", John Wiley & Sons, Inc., 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
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2. *Mr.Govardhana Giri, Director, Atalon Product Center Pvt, Ltd. giri@atalon.co*	2. *.Dr.Dheeraj K Khatod, Associate Professor,Dept. of EE, IIT-K*	2. *Mr. Jerome Stanley M , SRMIST*

Course Code	21AUE476T	Course Name	ENERGY STORAGE SYSTEMS FOR ELECTRIC AND HYBRID VEHICLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*gain information about the energy storage fundamentals such asbattery, solar cell and fuel cell in line to EV and hybrid vehicle technology*
CLR-2:	*familiarize the fundamental concept of Autonomous Vehicle Localization*
CLR-3:	*develop the knowledge of drive train and energy managementsystem design*
CLR-4:	*study the basics of fuel cells and hydrogen technologies and their applications*
CLR-5:	*grasp potential knowledge on EV case studies, charginginfrastructure and codes and standards*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*elaborate their knowledge on fundamentals of energy storage system for EV & hybrid vehicles*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze & interpret different EV architecture*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*demonstrate different powertrain technology & energy management systems for EV & hybrid vehicles*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*discuss different fuel cell technology with their challenges and applications*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*analyze various EVs in the global market, their codes & standards*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Energy Storage Systems ***9 Hour***

Fundamentals and Requirements of Energy Storage Systems for Electric Vehicles, Electrochemical Energy Storage Systems – Principle, Construction & Working Battery Characteristics, Energy Density and Ragone Plot, Advanced EV Batteries & Super Capacitors, Material Aspects in Battery technology, Hydrogen and Fuel cell technologies, Compressed Hydrogen Storage-EV, Material Aspects in Hydrogen Storage, Fuel cell: Fundamentals, Fuel Cell: Types, Fuel Cell- Efficiency and characteristics, Material Aspects in Fuel Cell, Solar PV for EV applications

Unit-2 - Wiring Layout and Design ***9 Hour***

Introduction to Electric Vehicles, Wiring Diagram/ Power Flow in EVs & HEVs z, Wiring Diagram/ Power Flow in EVs & HEVs , Types of EVs: HEV, FCEV, HEVs Configuration: Series- Case Study, HEVs Configuration: Parallel - Case Study, HEVs Configuration: Series Parallel- Case Study, Motor, Battery Pack, DC-DC Convertor, Inverter, On-Board Charger , Communication System, SMART HYBRID TECHNOLOGY - NEXA, Micro Hybrids - Case Study Electric Vehicle Charging- Fundamentals, Single and Multi-motor drives, In wheel drives,

Unit-3 - Fundamentals of Energy Management System ***9 Hour***

Energy Management Systems- Introduction, Battery Management Systems- Terminologies, BMS topologies: Centralized, Distributed, Modular:, BMS topologies: Centralized, Distributed, Modular:, Fundamentals of A.I for BMS, AI Algorithms for BMS, Kinetic energy recovery systems Flywheel Energy Storage System (FESS) Technology, Fuel cells energy, thermal & water management system, Fuel cells energy, thermal & water management system, Integrated Energy Management Systems, Range Extender, Numerical Problems, Case: Nissan Leaf vs Tesla, Case: Nissan Leaf vs Tesla

Unit-4 - Grid Architecture ***9 Hour***

ESS in micro-grid: Architecture, Introduction to Micro-grid and Smart grid, Technology, Subsystems in Micro-grid and Smart grid, Vehicle-to-Grid (V2G) Technology, Vehicle-to-Grid (V2G) Technology, Smart Charging (V1G) Technology, Vehicle-to-Grid (V2G) Technology, Microgrid-EV Integration, Microgrid-EV Integration, Limitations- Microgrid-EV Integration, Simulations- Microgrid-EV Integration-HOMER Software, Simulations- Microgrid-EV Integration- HOMER Software, Simulations- Microgrid-EV Integration-HOMER Software

Unit-5 - EV Market Scenario	***9 Hour***
EVs: National and International Overview, Techno-Economic Challenges of EVs, Codes & Standards for Batteries, Codes & Standards for Fuel Cells, Codes & Standards for Hybrid Electric Vehicles, Codes & Standards for hydrogen storage, Homologations for EVs, Case study 1- Charging infrastructure, Case study 2-Hydrogen refueling infrastructure, Case Study 3 – Nissan Leaf, Case Study 4 – Tesla Model S, Case Study 5 – Toyota Mirai, EV regulations: America vs Asia vs Europe, Contemporary Challenges Faced in Electric Vehicle Market	

Learning Resources	1. *Ehsani, M., Gao, Y., Longo, S. and Ebrahimi, K.M., 2018. Modern electric, hybrid electric, and fuel cell vehicles. CRC press.* 2. *Saudemont, C., Hissel, D., Roboam, X., Sareni, B.and Pouget, J., 2016. Electrical Energy Storage inTransportation Systems. John Wiley & Sons.*	3. *Saudemont, C., Hissel, D., Roboam, X., Sareni, B. and Pouget, J., 2016. Electrical Energy Storage in Transportation Systems.* 4. *John Wiley & Sons."Bosch' Automotive Handbook", 8thEdition*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
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Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

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2. *Mr.Govardhana Giri, Director, Atalon Product Center Pvt, Ltd. giri@atalon.co*		

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

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