ACADEMIC CURRICULA

Professional Elective Courses

AUTOMOBILE ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18AUE321T	Course Name	AUTOMOTIVE COMPONENTS MANUFACTURING	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:*	Learning		
		1	2	3
CLR-1 :	*acquire knowledge in understanding the manufacturing processes of automotive components*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	*understanding the professional and ethical responsibility*			
CLR-3 :	*Understand The process to meet desired needs within realistic*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the automotive component to be manufactured*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*H*	*M*	*H*	*M*	*L*	*M*	*M*	*H*	*H*	*M*
CLO-2 :	*Select the suitable materials for the component based on its functionality*	*2*	*95*	*90*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*H*	*M*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-3 :	*Identify the suitable manufacturing process for the component*	*2*	*90*	*85*	*H*	*H*	*M*	*M*	*L*	*L*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*H*	*M*
CLO-4 :	*Examine the primary & secondary machining operation.*	*2*	*95*	*90*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*H*	*M*	*L*	*M*	*M*	*H*	*M*	*M*
CLO-5 :	*Identify the possible defects and suggest suitable remedies*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*H*	*M*	*L*	*L*	*M*	*H*	*H*	*L*

Duration (hour)		Introduction to Automotive Engine Components	Manufacturing of Automotive Engine Components	Manufacturing of Air filters and catalytic converter of spark plugs	Manufacturing of glass & rubber processing technology	Manufacturing of Automotive body
		09	09	09	09	09
S-1	SLO-1	*Introduction to automotive engines - parts, Their function requirement,*	*Manufacturing of main bearing – Description, Purpose, Material-Production requirement – Consistent wall thickness, Precise crush height, process requirement*	*Manufacturing of Air filters-Description of Air filters, Functional requirement of air filters*	*Raw material preparation & melting-Properties of glass-Classification of glass for automotive application*	*Automotive materials-Automotive steel grades*
	SLO-2	*Material used in the automotive sector*	*Centrifugal casting Mold material, Consideration for main bearing in centrifugal casting.-Surface finishing for main bearing*	*Materials – Core materials, sealing agents, supporting materials.-Production*	*Glass melting furnace- Pot furnace, Day tank, Continuous tank, Electric furnace*	*High strength &ultra-strength-Stamping aluminum sheet*
S-2	SLO-1	*Manufacturing of an engine block of cylinder head-Functional requirement of an engine block*	*Manufacturing of main bearing cap-Functional requirement*	*Manufacturing of oil filters-Description of oil filters*	*Shaping process in glass working-Shaping of Glass- Spinning, processing, blowing*	*Automotive stamping process & die-Die operations & tooling*
	SLO-2	*cylinder head-Materials used in engine block casting*	*Material requirement – Special treatment materials for cap*	*Functional requirement of oil filters*	*Shaping of flat glass – Rolling, float, Drawing of glass tubs*	*Blank holder-Draw B*
S-3	SLO-1	*Manufacturing process –Low pressure die casting, High pressures die-casting, expendable pattern casting.*	*Production requirement-Process requirement – Hot chamber die casting*	*Manufacturing of oil filters-Materials*	*Forming of glass fibers-Centrifugal spraying*	*Blanking & sharing dies-Binding*
	SLO-2	*Machining–Cutting, Milling, Drilling, Boring, Honing, Reaming*	*Cold chamber die casting-Precision drilling operation*	*Manufacturing of oil filters-Production*	*Drawing of continuous filaments*	*Deep drawing-Coating & lubrication*
S-4	SLO-1	*Quality consideration during manufacturing*	*Vibration damper-Functional requirement, Description of vibration, Material requirement, Production requirement,*	*Manufacturing of ceramic catalytic convertor-Description of ceramic catalytic convertor*	*Heat treatment & finishing-Annealing*	*Advances in metal forming-Hydro forming & extrusion*

Duration (hour)		Introduction to Automotive Engine Components	Manufacturing of Automotive Engine Components	Manufacturing of Air filters and catalytic converter of spark plugs	Manufacturing of glass & rubber processing technology	Manufacturing of Automotive body
		09	09	09	09	09
	SLO-2	*Possible defects during manufacturing*	*Process description.-Vacuum casting Consideration for casting damper-Why vacuum casting & its advantages*	*Functional requirement*	*Tempered glass*	*Industrial origami : Metal folding – based forming-Flexible stamping procedure*
S-5	SLO-1	*Manufacturing of Camshaft-Functional requirement of Camshaft*	*Piston ring & pin-Description - types-Functional requirement*	*ceramic catalytic convertor-Material properties*	*Finishing – Primary design*	*Automotive TIG welding-Robotic spot welders*
	SLO-2	*Materials used in Camshaft, Production requirement-Process requirement*	*Material-Production requirement-Process requirement*	*Processing – Processing of starting materials, Shaping, sintering, finishing*	*secondary design considerations in glass processing*	*Adhesive bonding*
S-6	SLO-1	*Closed die forging, Impression die forging-forging force*	*Valves-Description, Functional requirement-Types of valves Monometallic, Bimetal, Stellied welded, Chrome plate, Nitrate*	*Manufacturing of metallic catalytic convertor-Description of ceramic catalytic convertor*	*Manufacturing of tires*	*Advances in automotive welding-Friction the welding*
	SLO-2	*Finishing operations. Heat treatment*	*Process – Cutting, Friction welding (Bimetal Special purpose), Upsetting, Forging, Stellied welding, Heat treatment, Grinding*	*metallic catalytic convertor Functional requirement*	*The construction of tires*	*Lack welding-Weld bonding*
S-7	SLO-1	*Manufacturing of crankshaft-Functional requirement of crankshaft*	*Automotive springs-Description, Functional requirement- Manufacturing process – Hot rolling, oil tempering, cold oiling,*	*metallic catalytic convertor Material properties-Need for honey comb structure is metal catalytic convertor*	*The production of tires*	*Automotive joining- automotive frame*
	SLO-2	*Materials used in crankshaft manufacturing*	*Stress relieving, Coil and grinding, nitriding, slot peering, Strain aging.*	*Methods of forming honey comb*	*The process of tires*	*Set assembling automotive doors*
S-8	SLO-1	*Production requirement*	*Inlet Manifold-Description, Functional requirement*	*Manufacturing of spark plug-Description of ceramic cat com*	*Performing of components*	*Final assembly-Installation of trim assembly*
	SLO-2	*Process requirement*	*Inlet Manifold Functional requirement*	*Functional requirement*	*Building the carcass*	*Installation of the chases-Final assembly & testing*
S-9	SLO-1	*Forging, Precision machining*	*Process Injection molding, Plastic materials,*	*Spark plug-Material selection*	*Molding of curing*	*Ergonomics of the final assembly*
	SLO-2	*Heat treatment*	*Injection molding, Injection molds.*	*Manufacturing of process – Processing of ceramic, forming of electrode, bonding.*	*Molding process*	*Mechanical fastening & bolting*

Learning Resources	1. *SeropeKalpakjian, "Manufacturing Engineering and Technology", 6th Edition,Addison-Wesley Publishing Co., Boston, 2010* 2. *Mohammed A. Omar, "The Automotive Body Manufacturing System and Processes"1st Edition, John Wiley & Sons Inc, USA, 2011.*	3. *Mikell P. Groover"Fundamentals of Modern Manufacturing", 4th Edition,John Wiley & Sons Inc, 2010* 4. *Benjamin W Niebel,"Modern Manufacturing Process Engineering", McGraw- HILL international editions*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc,

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. Dr. R.Rajendran, SRMIST, rajendrr@srmist.edu.in*
2. Mr.Dalpat Singh M & M, singh.dalpat@mahindra.com	*2. Dr.R.Elansezhian, Pondicherry Engineering College,elansezhianr@gmail.com*	*2. Mr. S.Madhan Kumar, SRMIST, madhanks@srmist.edu.in*

Course Code	18AUE322T	Course Name	WELDING AND JOINING TECHNIQUE	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency	Expected Attainment (%)
CLR-1 :	*Acquire knowledge on fusion welding processes and weld joints*			
CLR-2 :	*Select various welding process based on applications.*			
CLR-3 :	*List welding parameters and filler metals for various welding process*			
CLR-4 :	*Understand advanced welding techniques and its applications*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Categorize the various types of welding processes.*	*1*	*80*	*75*	*M*	*M*	*M*	*M*	*L*	*L*	*M*	*M*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-2 :	*Explain various arc welding techniques and its applications*	*2*	*85*	*80*	*H*	*H*	*M*	*L*	*M*	*M*	*M*	*M*	*H*	*L*	*M*	*M*	*M*	*H*	*M*
CLO-3 :	*Determine welding parameters for different types of materials*	*1*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*M*	*H*	*H*	*M*	*H*
CLO-4 :	*Predict the welding process suitable for automotive applications*	*2*	*80*	*75*	*H*	*H*	*L*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*
CLO-5 :	*Compare advanced welding with conventional welding techniques*	*2*	*75*	*70*	*H*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*M*

Duration (hour)		Welding Technology	Fusion Welding Processes	Weldability of metals and Allied Processes	Resistance Welding and Thermo-chemical welding	Solid state and high energy beam Welding
		9	9	9	9	9
S-1	SLO-1					*Friction welding*
	SLO-2	*Classification of fusion welding processes*	*Introduction to Arc Welding*	*Oxygen cutting*	*Spot welding and types of equipment*	*Diffusion joining and process variables and its applications,*
S-2	SLO-1					
	SLO-2	*Heat source intensity, Heat Input rates*	*Carbon arc welding*	*Flame cut ability of metals, effect of cutting on structure and properties of steel*	*Rocker arm press type welding and it's applications*	*Forge welding*
S-3	SLO-1					
	SLO-2	*Shielding methods*	*Gas tungsten arc welding*	*Oxygen lancing machine cutting, Powder cutting*	*Seam welding and its applications*	*Ultra sonic welding*
S-4	SLO-1					
	SLO-2	*Metallurgical effect of weld thermal cycle*	*Gas Metal Arc Welding*	*Welding of different types of materials - carbon and alloy steels.*	*Projection welding and its applications*	*Explosive welding*
S-5	SLO-1					
	SLO-2	*Residual stresses*	*Plasma arc welding*	*Welding of different types of materials - Cast iron non-ferrous metals and alloys, aluminum.*	*Flash and butt welding applications*	*Laser welding*
S-6	SLO-1					
	SLO-2	*Formation and Relieving*	*Submerged arc welding*	*Soldering and Brazing: Capillary and welding action*	*Gas welding ,fuel gases and flames*	*Electron beam welding -types of electron gun*
S-7	SLO-1					
	SLO-2	*Types of weld joints*	*Electro slag welding*	*Soldering and Brazing-Temperature Range*	*Torches, Filler metal and Fluxes*	*Electron beam welding- spot size beam power*
S-8	SLO-1					
	SLO-2	*Edge preparation, cleaning of edges*	*Arc welding applications*	*Filler Metals and Fluxes*	*Backward and Forward welding and filler rod diameter*	*Operating voltage, pulse technique, deep penetration and applications*
S-9	SLO-1					
	SLO-2	*Tack welding*	*Arc welding advantages and disadvantages*	*Processes and application, Design and strength of joints*	*Thermit welding*	*Other Joining Techniques for automotive applications*

Learning Resources	1. *Nadkarni. S. V, "Modern Arc Welding Technology", Ador Welding Ltd. Oxford and IBH Publishing, 2008.* 2. *William A. Bowditch, Kevin E. Bowditch, Mark A. Bowditch, "Welding Technology Fundamentals", Goodheart-Willcox Publisher, 4 edition, 2009*	3. *Richard L. Little, "Welding and welding Technology", TATA McGraw Hill Publishing Company Ltd, 1973.* 4. *Parmar. R. S, "Welding Engineering And Technology", Khanna Publishers, 2004*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*60%*		*50%*		*40%*		*15%*		*50%*	
	Understand										
Level 2	Apply	*40%*		*50%*		*60%*		*20%*		*50%*	
	Analyze										
Level 3	Evaluate	-		-		-		*15%*		-	
	Create										
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.N.Vijayakumar, Head Test labs, Mahindra and Mahindra, vijayakumar.n@mahindra.com.	*1. Prof. M.Balasubramanian, Professor, IIT Madras, mbala@iitm.ac.in*	*1.Dr.J.Chandradass,AutomobileEngg.SRMIST, chandraj@srmist.edu.in*
2. Mr.S. Senthil Kumar, Deputy Manager, Renault Nissan Technology & Business Centre India, senthilkumar.subramanian@rntbci.com	*2. Prof.V.Muthupandi, NIT Trichy, vmuthu@nitt.edu*	*2.Mr.G.Jesurajendran,AutomobileEngg SRMIST, jesurajg@srmist.edu.in*

Course Code	18AUE323T	Course Name	AUTOMOTIVE SURFACE ENGINEERING	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 :	*Describe the surface preparation techniques*
CLR-2 :	*Interpret the knowledge on thermal spraying technology for surface coating applications*
CLR-3 :	*Understand the process of Hot dip and diffusion coating*
CLR-4 :	*Illustrate the testing procedure for surface coating*
CLR-5 :	*Understand the testing and selection of coating*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design &	Analysis, Design, Research	Modern Tool	Society & Culture	Environment & Sustainability	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Select the various techniques of surface preparation*	*3*	*90*	*85*	*H*	*M*	*H*	*M*	*L*	*L*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*M*	*L*
CLO-2 :	*Identify the thermal spraying process and electrodeposited coating*	*1*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*-*	*M*	*M*	*-*	*M*	*M*	*M*	*H*
CLO-3 :	*Distinguish the process of Hot dip and diffusion coating*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*L*	*M*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-4 :	*Perform the testing procedure for surface coating*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*-*	*M*	*M*	*M*	*M*
CLO-5 :	*Analyze and select the coating for application*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*M*	*H*

Duration (hour)		Metal Cleaning and Surface Treatment	Thermal Spraying Processes	Coatings	Non-Metallic coating oxide and Corrosion	Testing and Selection of coatings
		09	09	09	09	09
S-1	SLO-1	*Need and relevance of surface engineering*	*Classification of Thermal spraying*	*Principles – surface preparation batch coating*	*Plating coating*	*The quality plan, Design*
	SLO-2	*Pre-treatment of coating*	*Thermal barrier and Thermal conductive coatings*	*Continuous coating process*	*Lacquers*	*Testing and inspection of thickness measurement*
S-2	SLO-1	*General cleaning process for ferrous metals*	*Thermal spraying – flame*	*Properties of Coatings*	*Rubbers*	*Adhesion*
	SLO-2	*General cleaning process for non-ferrous metals*	*Arc spraying method*	*Applications of coatings*	*Elastomers*	*Resistance*
S-3	SLO-1	*Selection of cleaning process*	*Plasma Processes*	*surface treatments in wear*	*Vitreous enamels*	*Porosity measurement*
	SLO-2	*Alkaline cleaning*	*HVOF processes*	*Friction control*	*Anodizing phosphating and chromating*	*Selection of coatings*
S-4	SLO-1	*Emulsion cleaning*	*PLV process*	*Thick coatings*	*Application to Aluminium, Magnesium, Tin, Zinc, Cadmium Copper and Silver*	*Industrial applications of engineering coatings*
	SLO-2	*Ultrasonic cleaning*	*Coating production*	*Principles of cementation*	*Phosphating primers*	*Basic mechanisms of wear*
S-5	SLO-1	*Acid bath descaling*	*Spray consumables*	*Cladding*	*Principle of Corrosion*	*Abrasive Wear*
	SLO-2	*Pickling salt bath descaling*	*Principles of electroplating*	*Diffusion coating of C.N. Al, Si, Cr and B*	*Classification of corrosion*	*adhesive wear*
S-6	SLO-1	*Abrasive bath cleaning*	*Technologies used in electroplating systems*	*Corrosion resistant coatings*	*Types of corrosion*	*contact fatigue*
	SLO-2	*Surface treatment of gears*	*Factors affecting the electroplating process*	*Properties of diffusion coatings*	*Factors influencing corrosion*	*fretting corrosion*
S-7	SLO-1	*Short peening*	*Properties and Faraday's Law*	*Application of diffusion coatings*	*Corrosion protection of ferrous and non-ferrous components*	*Salt spray test*
	SLO-2	*Blasting*	*Factors affecting throwing power*	*Nano-engineered coatings*	*Testing and Prevention of Corrosion*	*Humidity test*

Duration (hour)		Metal Cleaning and Surface Treatment	Thermal Spraying Processes	Coatings	Non-Metallic coating oxide and Corrosion	Testing and Selection of coatings
		09	09	09	09	09
S-8	SLO-1	*Machining*	*Electroplating*	*Wear resistant coatings*	*Material selection*	*Porosity test*
	SLO-2	*Boronizing*	*Applications of electroplating*	*Characteristics of Wear resistant coatings*	*Alteration of environment*	*Susceptibility tests for intergranular corrosion Stress*
S-9	SLO-1	*Carbonitriding*	*Non-aqueous*	*Physical vapor deposition*	*surface treatments on Gears*	*Corrosion test*
	SLO-2	*Aluminising*	*Electroless deposition*	*Chemical vapor deposition*	*Corrosion inhibitors*	*Testing wear resistance practical diagnosis of wear*

Learning Resources	
1. *George Dieter "Mechanical Metallurgy", McGraw Hill Education; 2012* 2. *Rabinowicz.E, "Friction and Wear of materials", Second Edition: John Willey &Sons, UK, 2013.* 3. *DeGarmo's "Materials and Processes in Manufacturing" J.T. Black, Ronald A. Kohser, Wiley, 2011.* 4. *S.K.Basu, S.N.Sengupta & B.B.Ahuja ,"Fundamentals of Tribology", Prentice –Hall of India Pvt Ltd, New Delhi, 2005*	5. *G.W.Stachowiak& A.W .Batchelor , "Engineering Tribology", Butterworth-Heinemann, UK, 2005* 6. *Stand Grainger engineering coatings – design and application jaico publishing House, 1994.* 7. *Parthasarathy. N.V., Electroplating Handbooks, Prentice Hall, 1992*

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr K Venkateswaran, Bimetal Bearings Limited, drvenki@bimite.co.in	*1. Dr V. Umasankar, VIT, umasankar.v@vit.ac.in*	*1. Dr. R Rajendran, SRMIST, rajendrr@srmist.edu.in*
2. Mr S. Srinivasan, Ashok Leyland, srinchand@gmail.com	*2. Dr R. Elansezhian, Pondicherry Engineering College, elansezhianr@gmail.com*	*2. Mr. S. Logeshwaran, SRMIST, logeshws@srmist.edu.in*

Course Code	18AUE324T	Course Name	AGILE MANUFACTURING	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 manufacturing system and operation in terms of economic and technology.*
CLR-2 :	*Learn the manufacturing categories, material handling and manufacturing product*
CLR-3 :	*Expertise in industrial automation levels and its functional requirement*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify the lean manufacturing tools and their potential applications.*	*1*	*85*	*80*	*H*	*H*	*L*	*M*	*L*	*L*	*L*	*L*	*H*	*L*	*M*	*H*	*H*	*M*	*H*
CLO-2 :	*Summarize the usage of visual management, TPM and lean practices*	*2*	*80*	*75*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*H*	*L*	*H*	*H*	*H*	*L*	*H*
CLO-3 :	*Compare the technology drivers of agile manufacturing*	*2*	*85*	*80*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*L*	*H*	*H*	*H*	*M*	*M*
CLO-4 :	*Demonstrate the lean manufacturing principles to find and eliminate wastes*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*L*
CLO-5 :	*Explain the technology drivers of agile manufacturing*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*M*

Duration (hour)		Introduction to Manufacturing Operations	Manufacturing System	Supply Chain Management, Production Planning & Control System	Lean Production : JIT, Value Added & Waste Elimination	Agile Manufacturing
		09	09	09	09	09
S-1	SLO-1	*Introduction to Manufacturing Operations*	*Manufacturing System- Definition*	*Supply Chain Management*	*Introduction to various manufacturing techniques*	*Agile Manufacturing*
	SLO-2	*Definition of Manufacturing*	*Material Handling- Definition*	*Importance of supply chain-Definition*	*Introduction to lean production-importance*	*Introduction-Definition-Organize to master change*
S-2	SLO-1	*Alternate Definition of Manufacturing system as Technological*	*Human Resource Manufacturing system in large production system*	*competitive industrial revolution*	*Components of lean production*	*leverage the impact of People & information*
	SLO-2	*Economic Process Comments - Remarks*	*Components of a manufacturing system*	*Relying on Suppliers-downside and upside*	*Minimizing waste, perfect first time quality*	*cooperate to enhance competitiveness-enrich the customers*
S-3	SLO-1	*Manufacturing Industries & Products Manufacturing Categories –Primary – Secondary – Territory*	*Various components- Production machines*	*Supply chain management-Physical supply chain*	*flexible production line, continuous improvement*	*Market force & agility*
	SLO-2	*Continuous & Batch Production – Discrete manufacturing industry. Manufacturing Products – Materials, Typical Product*	*Tools, fixtures & material handling system*	*management philosophy*	*Definitions, Functions, & Principles.*	*Intensifying competition-fragmentation of mass market*
S-4	SLO-1	*Manufacturing Operation-Processing & Assembly operations-Material handling*	*Computer systems to coordinate the manufacturing system*	*Purchasing-changing roles*	*Smart inventory waste minimization*	*cooperative business relationship*
	SLO-2	*Inspection & testing-Coordination & testing-Process, Objective, Working & Stages of operations*	*Human Workers*	*requirement specifications*	*JIT- Concept*	*Changing customer expectation*
S-5	SLO-1	*Product & Production Relationship*	*Classification of Manufacturing systems*	*suppliers, assessment, selection & contracting*	*waste of over production*	*Reorganizing the production system for agility-design*

Duration (hour)		Introduction to Manufacturing Operations	Manufacturing System	Supply Chain Management, Production Planning & Control System	Lean Production : JIT, Value Added & Waste Elimination	Agile Manufacturing
		09	09	09	09	09
	SLO-2	*Production quantity & product variety*	*Factors – Types of operation performed*	*managing supplier relationship*	*waste of waiting*	*Reorganizing the production system for agility-product*
S-6	SLO-1	*Complexity of assembled products-Complexity of individual parts*	*number of work stations & layout*	*Material Requirement Planning (MRP) inputs to MRP, Bill of materials,*	*waste of transportation, waste of processing*	*Reorganizing the production system for agility-marketing*
	SLO-2	*Operations, functions, capabilities, limitation & examples*	*level of automation- product variety.*	*Product Structure, working- Examples, output & benefits of MRP*	*waste of motion*	*Reorganizing the production system for agility production operation*
S-7	SLO-1	*Production Concept & Mathematical Models-Production rate*	*Overview of Classification of manufacturing systems*	*Capacity Planning*	*waste of making defective parts*	*Agility versus Mass production*
	SLO-2	*Production capacity-utilization & availability of facility*	*single station*	*Shop Floor Control- order release, scheduling & Progress. Data collection.*	*Objectives of JIT*	*Agility versus Mass production*
S-8	SLO-1	*Manufacturing Lead time-Work in Process*	*Multi station*	*Inventory Control- Order point inventory system*	*Ingredients of JIT*	*Comparison of Lean & agile production*
	SLO-2	*objective, Operations, Functions & examples*	*production lines*	*work in process (WIP) inventory cost*	*Quality & Quantity principles of JIT*	*Comparison of Lean & agile production*
S-9	SLO-1	*Costs of Manufacturing Operations-Fixed & variable cost- Definition, cost equation & application-Direct Labor- Definition, Equation, Application & Examples*	*Learning curves of manufacturing progress-Definition*	*Manufacturing Resource Planning II (MRP II)*	*Primary quantity JIT principles*	*implementation of agile manufacturing*
	SLO-2	*Material & overhead- Factory & cooperate.- Estimating manufacturing Cost & establishing selling price-Cost of Equipment*	*learning rates for typical operations*	*Definition, structure, working & application*	*JIT implementation*	*implementation of agile manufacturing*

Learning Resources	1. *Mikell P. Groover "Automation, Production System & Computer Integrated Manufacturing ", Prentice Hall; 3 edition (August 3, 2007)* 2. *John M. Nicholas "Competitive Manufacturing Management" 9th Edition, TATA McGraw Hill editions* 3. *S.R.K. Prasad, R. Prabhakar, S. Dhandapani, V. Selladurai " Intelligent Flexible Autonomous Manufacturing Systems", TATA McGraw- Hill Publishing Company Limited, 2010* 4. *M. P. Chowdiah, Gopinath Gargesa, V. Arun Kumar, "Agile Manufacturing:, TATA McGraw- Hill Publishing Company Limited, 2006*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr K Venkateswaran, Bimetal Bearings Limited, drvenki@bimite.co.in	*1. Dr.R.Elansezhian, Pondicherry Engineering College,elansezhianr@gmail.com*	*1. Dr. R.Rajendran, SRMIST, rajendrr@srmist.edu.in*
2. Dr.G.Saravanan Caterpillar, gsaravanan@cat.com	*2. Mr. N.Ravikumar, Crescent Institute of Science and Technology, ravikumar@crescent.education*	*2.Mr. S.Madhan Kumar, SRMIST, madhanks@srmist.edu.in*

Course Code	18AUE325T	Course Name	MANUFACTURING SYSTEMS AND SIMULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC201J*	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 :	*Provide an insight into how simulation modelling can aid in effective decision-making.*
CLR-2 :	*Create Simulation model building aspects of discrete systems (such as Queuing, Inventory and manufacturing) in detail.*
CLR-3 :	*Demonstrate how computer simulation can be used to successfully model, analyze and improve systems under study.*
CLR-4 :	*Perform the statistical analysis of simulation model output.*
CLR-5 :	*Selection of the appropriate simulation software for the different cases.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Learn the basic concepts of simulation.*	*1,2*	*90*	*85*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-2 :	*Develop and analyze complex models for industrial engineering problems using commercially available discrete event simulation software*	*2*	*90*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-3 :	*Interpret simulation output using valid statistical methods and make appropriate recommendations.*	*2*	*90*	*80*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*H*
CLO-4 :	*Analyze data to determine appropriate input distributions using valid statistical methods.*	*2*	*90*	*80*	*H*	*H*	*M*	*H*	*M*	*L*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*H*
CLO-5:	*Apply the simulation software for various manufacturing system/process*	*2*	*90*	*80*	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*M*

Duration (hour)		Introduction to Manufacturing Systems	Manufacturing System Modeling and Simulation	Random Number Generation	Evaluation of Simulation Experiments	Simulation software and Examples
		9	9	9	9	9
S-1	SLO-1	*Basic concepts and problems concerning systems*	*Basic concepts ofprobability-*	*Properties of random numbers*	*Input modeling, Data collection*	*Programming for discrete event system simulation in GPSS-*
	SLO-2	*Components of Manufacturing systems*	*Discrete versus Continuous Variables*		*Histograms, Selecting the family distribution,*	
S-2	SLO-1	*Systems design: Decision making procedures*	*Probability distribution for discrete variables*	*Techniques for generating random numbers- Linear Congruential Method*	*Selecting input distributions with data*	*GPSS- Single Server Queue simulation*
	SLO-2	*Classifications of Manufacturing systems*	*Probability distribution for continuous variables*		*Quantile-Quantile plots*	
S-3	SLO-1	*Structural, Transformational and procedural aspects of manufacturing*	*Binominal Distribution- to test hypothesis*	*Techniques for generating random numbers- Combined Linear Congruential Generator.*	*Parameter estimation- sample mean and sample variance*	*Simulation of Production systems- Models of Material Handling system.*
	SLO-2				*Suggested estimators*	
S-4	SLO-1	*Modes of production- Batch Production, Cellular, Flexible Manufacturing.*	*Statistical Models- Queueing Systems, Inventory and Supply chain system*	*Techniques for generating random numbers- Random- Number streams*	*Goodness-of-fit tests Chi-square test*	*Simulation of Production systems- Models of Material Handling Equipment.*
	SLO-2		*Reliability and Maintainability*		*Chi-square test with equal probabilities*	
S-5	SLO-1	*Process systems for manufacturing*	*Spread Sheet simulations*	*Tests for random numbers- Frequency Test.*	*Kolmogorov-smirnov goodness of fit test*	*Queueing Systems- Characteristics*
	SLO-2				*p-value and best fits*	
S-6	SLO-1		*Queueing simulation in a spread sheet*		*Selecting input models without data*	*Queueing Systems- Notations*

Duration (hour)		Introduction to Manufacturing Systems	Manufacturing System Modeling and Simulation	Random Number Generation	Evaluation of Simulation Experiments	Simulation software and Examples
		9	9	9	9	9
	SLO-2	*Logistic systems- Product-Production Relationship*	*Waiting line models*	*Tests for random numbers- Test for Autocorrelation.*		
S-7	SLO-1	*Material flow & technological information flow*	*Simulating a single server queue*	*Direct transformation for acceptance and rejection techniques- Poisson Distribution*	*Multivariate and time series input models*	*Project networks*
	SLO-2		*Simulating a queue with two servers*	*Nonstationary Poisson process & Gamma Distribution.*	*Covariance and correlation*	
S-8	SLO-1	*Management and information systems for manufacturing*	*Discrete and Continuous Systems*	*Inverse Transform Techniques- Exponential Distribution, Uniform Distribution*	*Time-series input models*	*Maintenance and replacement systems*
	SLO-2		Discrete- Event system simulation	*Inverse Transform Techniques- Weibull Distribution, Triangular Distribution*		
S-9	SLO-1	*Managerial information flow in manufacturing systems*	*Concepts in Discrete- Event system simulation*	*Inverse Transform Techniques- Emphatical continuous distributions.*	*experimental layout and validation*	*Investment Analysis*
	SLO-2			*Inverse Transform Techniques- Discrete distribution.*		

Learning Resources	
	1. *Jerry Banks and John S Carson, Barry L Nelson, David M Nicol, 'Discrete event system simulation',5th editionPearson Education, 2017, ISBN 13: 9789332518759.* 2. *David Bedworth& James Bailey, Integrated production control system management, analysis & design, 2nd ed., John Wiley & Sons Ltd, 1987, ISBN 13: 9780471821793* 3. *Carrle A, "Simulation of Manufacturing Systems", John Wiley and Sons Inc., New York, 2007, ISBN 13: 9780471915744* 4. *Gordon G, "Systems Simulation", Pearson Education, 2002.ISBN 13: 9788120301405* 5. *Narsingh Deo, "System Simulation with Digital Computer", Prentice Hall of India, New Delhi, 2001.ISBN 13: 9780138817893*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*60%*		*50%*		*40%*		*15%*		*50%*	
	Understand										
Level 2	Apply	*40%*		*50%*		*60%*		*20%*		*50%*	
	Analyze										
Level 3	Evaluate	-		-		-		*15%*		-	
	Create										
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. . Mr.N.Vijayakumar, Head Test labs, Mahindra and Mahindra, vijayakumar.n@mahindra.com.	*1. Dr. A.Siddharthan, Madras Institute of Technology, sidharth@mitindia.edu*	*1.Dr.J.Chandradass,SRMIST, chandraj@srmist.edu.in*
2. Mr.S. Senthil Kumar, Deputy Manager, Renault Nissan Technology & Business Centre India, senthilkumar.subramanian@rntbci.com	*2. Dr. S. Renold Elsen, Vellore Institute of Technology, renoldelsen.s@vit.ac.in*	*2. Mr.M.Jerome Stantley, SRMIST, jeromesm@srmist.edu.in*

Course Code	18AUE326T	Course Name	COMPOSITE MATERIALS AND STRUCTURES	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 :	Study the reinforcements and matrix materials of polymer matrix composites, metal and ceramic matrix composites.
CLR-2 :	Understand the micro mechanical and macro mechanical behavior of lamina and laminate
CLR-3 :	Develop knowledge on processing and advances in composites.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design,	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Understand the basics of reinforcements and matrix materials	1	90	85	H	M	H	H	H	M	M	L	M	M	L	M	H	H	H
CLO-2 :	Evaluate the micro mechanical properties of lamina	1,2,3	90	80	H	M	H	H	H	L	L	L	M	M	L	M	H	H	H
CLO-3 :	Classify the type of laminate and understand the concept of sandwich composite	1,2,3	90	80	H	M	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-4 :	Select suitable manufacturing process for different types of composites	1,3	90	90	H	H	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-5 :	Acquire knowledge on advances in composite materials	1,3	90	85	H	H	H	H	M	L	L	L	M	M	L	M	H	H	H

Duration (hour)		Introduction to composites	Micro Mechanical Analysis of lamina	Macro Mechanical Analysis of Laminate /Sandwich composites	Manufacturing process	Advances in Composites
		9	9	9	9	9
S-1	SLO-1	Fundamentals of composites	Volume fractions	Laminate code	Polymer Matrix Composite-Hand lay up	Carbon /Carbon composites
	SLO-2	Need for composites	Mass fractions		Spray lay up	Carbon Fiber Reinforcements
S-2	SLO-1	Classification of composites	Problems based on volume and mass fractions	Special cases of laminates-Symmetry, Angle ply, Cross ply, Antisymmetric and Balanced laminate	Compression moulding	Matrix Systems-Thermosetting
	SLO-2	Properties and function of reinforcement and matrix	Derivation of density of composite and related problems			
S-3	SLO-1	Reinforcement materials-Glass fibre Disadvantage of Composite	Derivation of Elastic modulus under Longitudinal Loading,	One Dimensional Isotropic beam stress strain relation	Injection moulding	Thermoplastic and Gaseous precursor
	SLO-2	Reinforcement materials- C fibre, Kevlar	Problems on Elastic modulus under Longitudinal Loading,			
S-4	SLO-1	Matrix Materials-Polymer –Thermoset-Polyester, epoxy	Derivation of Elastic modulus under Transverse Loading	Classical lamination theory	Filament winding	Processing of C/C Composites
	SLO-2	Matrix Materials-Polymer –Thermoset-Phenolic, vinyl ester	Problems on Elastic modulus under Transverse Loading		Pultrusion	Thermosetting Resin Based Processing
S-5	SLO-1	Matrix Materials-Polymer - Thermoplastics	Major and Minor poisson ratio and related problems	Failure criteria for a laminate	Metal Matrix Composite-Powder Metallurgy	Thermoplastic Pitch Based Processing
	SLO-2		In plane shear modulus derivation and problems			Chemical Vapor Infiltration
S-6	SLO-1	Matrix Materials-Metals	Ultimate strength of unidirectional lamina-longitudinal tensile strength	Sandwich composite-Basic concepts	Diffusion bonding	
	SLO-2			Materials used for sandwich construction	Stir Casting, Squeeze casting	Properties of C/C Composites Oxidation Protection of C/C composites

Duration (hour)		Introduction to composites	Micro Mechanical Analysis of lamina	Macro Mechanical Analysis of Laminate /Sandwich composites	Manufacturing process	Advances in Composites
		9	9	9	9	9
S-7	SLO-1	Matrix Material-Ceramics	Problems related to longitudinal tensile strength	Sandwich structure-Design consideration	Ceramic Matrix Composite-Hot pressing	Oxidation Protection of C/C composites Application of C/C Composites
	SLO-2		Longitudinal compressive strength			Nanocomposites
S-8	SLO-1	Advantages of Composite	Transverse tensile and Transverse compressive strength	Sandwich construction	Slurry Infiltration and Sol-gel process	Polymer Nanocomposites
	SLO-2	Disadvantage of Composite	In plane shear strength	Benefits of sandwich construction		Metal Nanocomposites
S-9	SLO-1	Applications of composite	Co-efficient of thermal expansion and moisture expansion	Failure modes of sandwich structure	Joining and Machining of composite	Ceramic Nanocomposites
	SLO-2		Theories of failure			Nanocomposites- Properties and Applications

Learning Resources	
1. M. Balasubramanian, "Composite Materials and Processing", CRC press, Taylor and Francis Group, 2014. 2. Autar K. Kaw, " Mechanics of Composite Materials", Second Edition, CRC press, Taylor and Francis Group, 2006.	3. Sanjay K Mazumdar, "Composites Manufacturing: Materials, Product and Process Engineering", CRC Press, New York, 2010. 4. ASM Handbook – Composites, Vol-21, 2001

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	100 %	-	30 %	-	50 %	-	40 %	-	40 %	-
	Understand										
Level 2	Apply	-	-	30 %	-	50 %	-	30 %	-	30 %	-
	Analyze										
Level 3	Evaluate	-	-	40%	-	-	-	30%	-	30%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.N.Vijayakumar, Head Test labs, Mahindra and Mahindra, VIJAYAKUMAR.N@mahindra.com.	1. Prof. M.Balasubramanian, Professor, IIT Madras, mbala@iitm.ac.in	1. Dr. J.Chandradass, , SRMIST, chandraj@srmist.edu.in
2.Mr. Prasad Arun Kumar, Mahindra Research Valley, prasad.arunkumar@mahindra.com	2. Dr.P.Jawahar, Assistant Professor, NIT Agartala, drjawahar.me@nita.ac.in	2. Dr.R.Rajendran, SRMIST,rajendrr@srmist.edu.in

Course Code	18AUE327T	Course Name	METROLOGY AND MEASUREMENTS	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 :	Inspection of engineering parts with various precision instruments
CLR-2 :	Principles of measuring instruments and gauges and their uses
CLR-3 :	Evaluation and inspection of surface roughness.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design,	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Understand the methods of measurement and selection of measuring instruments, standards of measurement	1	95	90	H	M	H	H	H	M	M	H	H	M	H	H	H	H	M
CLO-2 :	Use instruments for linear and angular measurement Use devices for gear, screw threads and surface finish measurements	2	90	87	H	H	M	H	H	M	M	M	H	M	H	H	H	H	L
CLO-3 :	Determine geometry and dimensions of components in engineering applications	2	95	92	H	M	H	H	H	M	L	H	H	M	H	H	H	M	M
CLO-4 :	Interpret characteristics of measuring instruments	2	90	85	H	H	M	H	H	M	M	M	H	M	H	H	H	H	L
CLO-5 :	Evaluate methods of measurement for various physical quantities	2	90	86	H	M	M	H	H	M	L	H	H	M	H	H	H	M	M

Duration (hour)		Basics Of Metrology	Linear And Angular Measurements	Machine Tool Metrology	Basics Of Measurement	Form, Power, Flow And Temperature-Measurement
S-1	SLO-1	Introduction to Metrology	Linear Measuring Instruments	Advanced measuring devices	Mechanical Measurements	Principles and Methods of straightness
	SLO-2	Need for inspection	Evolution	Principle of Interferometers	Introduction to measurement and measuring instruments	Flatness measurement
S-2	SLO-1	Physical measurement	Types of Linear Measuring Instruments	Laser interferometers	General concept	Thread measurement
	SLO-2	Elements of measurement	Classification of Linear Measuring Instruments	IntroductionCoordinate Measuring Machine (CMM)	Generalized measurement system	Gear measurement
S-3	SLO-1	Work piece	Limit gauges	Components of CMM	its elements	Surface finish measurement
	SLO-2	measuring instruments	gauge design	Construction of CMM	Unit sand standards measuring instruments	Roundness measurement
S-4	SLO-1	Environment aspects	Terminology and procedure	Types of CMM	sensitivity, stability, range,	Applications
	SLO-2	Effect on Precision and Accuracy	Concepts of interchange ability	Advantages and application of CMM	accuracy and precision	Force, torque, power
S-5	SLO-1	Errors	Selective assembly	CMM probes	Static response	Mechanical , Pneumatic
	SLO-2	Errors in Measurements	Angular measuring instruments	Types of probes	Dynamic response	Hydraulic and Electrical type
S-6	SLO-1	Types of Errors	Types of Angular measuring instruments	contact probes	Repeatability	Flow measurement: Venturimeter
	SLO-2	Error Control	Bevel protractor	Non- contact probes	Systematic	Orifice meter
S-7	SLO-1	StandardsLimits, Fits	clinometers angle gauges	Introduction to machine vision	Source of error	rotameter, pitot tube
	SLO-2	Tolerances: Tutorial	spirit levels sine bar	Need for Machine Vision	Statistical analysis of error	Temperature: bimetallic strip,
S-8	SLO-1	Introduction to Comparators	Angle alignment telescope	functions	Random errors	thermocouples
	SLO-2	Mechanical(Sigma)	Applications	applications	Correction , calibration	electrical resistance thermometer
S-9	SLO-1	Electrical	Autocollimator	advantages of machine vision	Dimensional tolerance	Reliability
	SLO-2	Pneumatic comparator	Applications	Steps in machine vision	Geometric tolerance	Calibration

Learning Resources	*TEXT BOOKS* *1.Metrology & Measurement by Bewoor, McGraw HillISBN-9780070140004-2017* *2.Engineering Metrology, byR K JainKhanna PublishersISBN: 9788174091536, 817409153X Edition: 2004*	*REFERENCE BOOKS* *1. Mechanical Measurements and Instrumentationby R.K. RajputISBN 13: 9789350142851- 2013-EDN-1*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Dalpat Singh, M & M,singh.dalpat@mahindra.com	*1. Mr.J.MahasharAli,Crescent Institute of Science and Technology, mahashar@crescent.education*	*1. Mr..S.Madhan Kumar, SRMIST*
2. Mr. Nirmal Kumar, Hubell India, nirmal06kumar@gmail.coml	*2. Dr.K.Kalaichelvan, Anna University, kalaichelvan@annauniv.edul*	*2. Dr.R.Rajendran, SRMIST*

Course Code	18AUE421T	Course Name	ADVANCED MANUFACTURING PROCESS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC201J*	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:*	Learning		
		1	2	3
CLR-1 :	*Acquire knowledge of various advanced manufacturing processes used in industries*			
CLR-2 :	*Understand the various manufacturing process of composite, plastics and glass.*			
CLR-3 :	*Acquaint students with the concept of Additive Manufacturing (AM), various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify the advanced metal forming process and its current role in the industries.*	*1*	*85*	*75*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-2 :	*Choose the manufacturing process for the fabrication of composite, plastics and glass depending on the applications.*	*3*	*80*	*75*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Integrate microelectronic device for Automotive application*	*3*	*85*	*80*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*L*	*M*	*L*	*H*	*H*	*H*
CLO-4 :	*List the low temperature joining and surface treatment process.*	*1*	*85*	*80*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*M*	*H*	*L*	*L*	*H*	*H*	*H*
CLO-5 :	*Select economically viable manufacturing process of highly complex parts alternative to conventional manufacturing technologies*	*3*	*80*	*75*	*H*	*M*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*M*	*H*	*H*	*H*

Duration (hour)		Advanced Metal Forming Process	Composites, Plastics & Glass: Forming, Shaping & Equipment	Fabrication of Microelectronic Devices	Low Temperature Joining Process & Surface Technology	Additive Manufacturing
		9	9	9	9	9
S-1	SLO-1	*Introduction – why do we need advanced manufacturing process?*	*Introduction to Composites*	*Role of Electronics in Industrial Revolution.*	*Introduction to joining process*	*Introduction to additive manufacturing.*
	SLO-2	*Introduction to powder metallurgy technique.*	*Composites properties and structures.*	*Integration of Electronics in Automotive Industry.*	*Brazing & Soldering methods- torch, furnace, induction, resistance, dip, infrared and applications.*	*Importance of Rapid prototyping.*
S-2	SLO-1	*Need and role of powder metallurgy in Automotive industry.*	*Processing of Polymer Matrix composites- Compression molding, injection molding , hand lay-up method , filament winding*	*Semiconductors & Silicon- Structure, Physical Properties.*	*Adhesion bonding – types of adhesives and adhesives system – Applications*	*RPT – classification based on materials, Advantages*
	SLO-2	*Powder Metallurgy Applications – Automotive parts and components.*	*Processing of Metal Matrix composites. Stir casting process , squeeze casting process/ infiltration , diffusion bonding, powder metallurgy*	*Semiconductors – working and types.*	*Joining of Plastics*	*Liquid based techniques- overview*
S-3	SLO-1	*Production and properties of metal powders.*	*Processing of Ceramic Matrix Composites Chemical vapor infiltration, Sol-gel Process*	*Semiconductors – advantages.*	*Joining of ceramics Joining of glass.*	*Stereo lithography.*
	SLO-2	*Particle size, distribution and shape of metal powders.*	*Composites in Automotive applications.*	*Wafer Formation & preparation*	*Surface Treatment- need, surface structure.*	*Solid Ground Curing technique.*
S-4	SLO-1	*Blending of metal powders and purpose.*	*Shaping of plastics*	*Single Crystal growing Techniques.*	*Mechanical surface treatment – shot peening, laser shot peening*	*Multi Jet Modeling,*
	SLO-2	*Hazards in Blending, Compaction of Metal powders.*	*Injection Molding process.*	*Slicing of wafers Geometry of wafers.*	*Water jet peening,*	*Ballistic particle.*

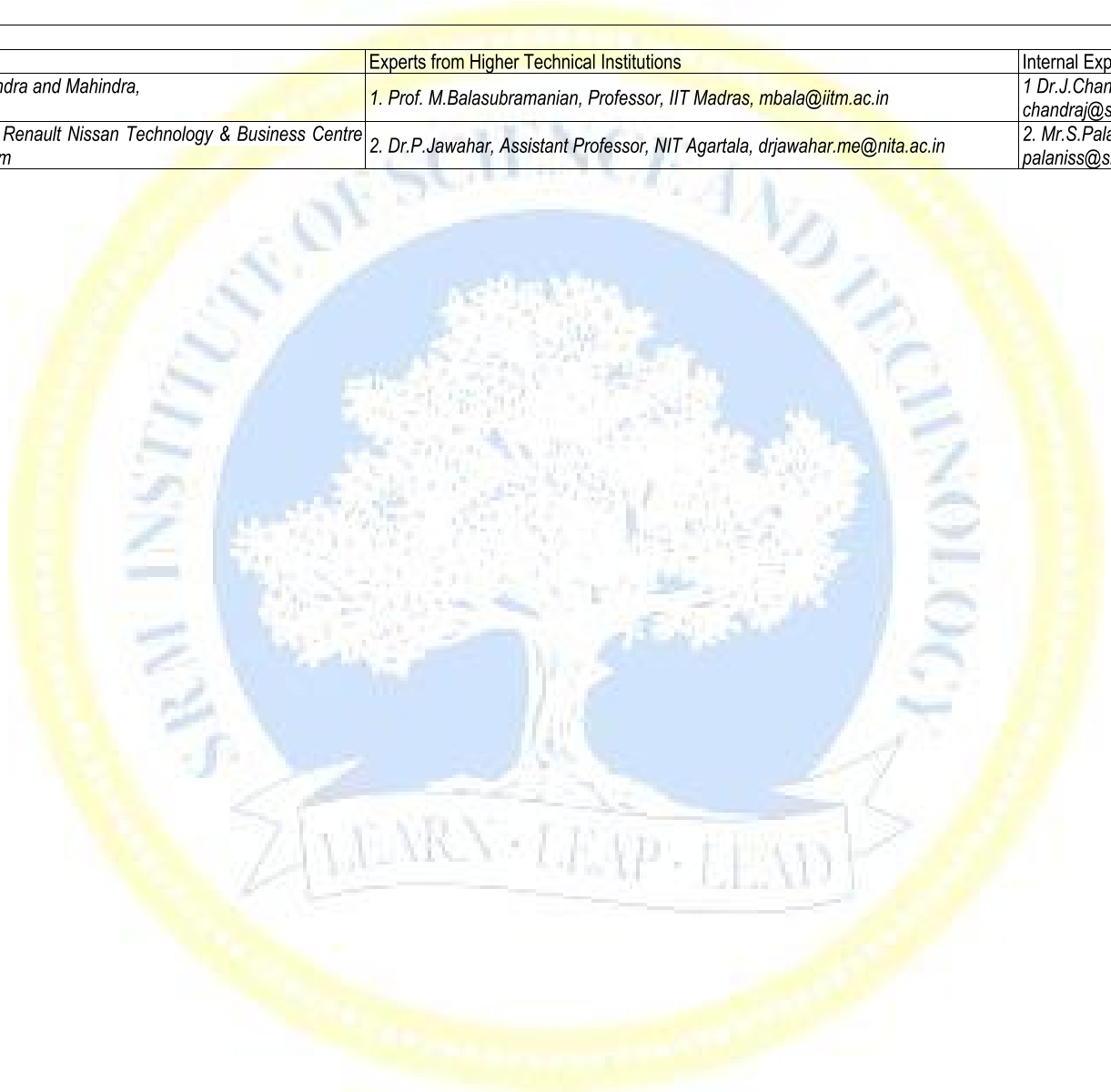
Duration (hour)		Advanced Metal Forming Process	Composites, Plastics & Glass: Forming, Shaping & Equipment	Fabrication of Microelectronic Devices	Low Temperature Joining Process & Surface Technology	Additive Manufacturing
		9	9	9	9	9
S-5	SLO-1	*Purpose of Isotactic pressing.*	*Blow Molding process*	*Film Deposition & Oxidation techniques.*	*Ultrasonic peening*	*Shape deposition Manufacturing*
	SLO-2	*Hot & Cold Shaping Process.*	*Rotational Molding process.*	*Physical Vapor Deposition*	*surface rolling - operation*	*Powder based techniques- overview*
S-6	SLO-1	*Metal injection molding, Spray Deposition.*	*Thermoforming process.*	*Chemical Vapor Deposition*	*explosive hardening - operation*	*Selective laser sintering.*
	SLO-2	*Sintering – process, Coining, Forging.*	*Compression molding process*	*Photolithography – Principle and Process.*	*Cladding - process & working*	*Laser engineered net shaping.*
S-7	SLO-1	*Mechanism and Properties of Sintered Parts Secondary & Finishing Operations.*	*Transfer Molding process.*	*Photolithography - Types & working*	*Case hardening - process & working*	*3D printing – introduction*
	SLO-2	*Heat treating, Impregnation, Infiltration & Plating.*	*Economics of Processing Plastics & Composites.*	*Etching – Need, Types, Principle.*	*Hard facing - objective, process & working.*	*3D printing- working and application*
S-8	SLO-1	*Dent Resistance of Sheet metals – dent formation &automotive application.*	*Forming & shaping of Glass- piece ware glass- spinning , pressing , press and blow , blow & blow and casting*	*Etching - Process & Working*	*Spark hardening - objective, process & working*	*Solid based technique- overview*
	SLO-2	*Fabrication of Honey Comb Structure for Catalytic Convertor.*	*Flat and tubular glass- float process , rolling of flat plate , Danner process*	*Diffusion- Principle, Process & Working*	*Thermal spraying – need, materials*	*Fused Deposition Modeling*
S-9	SLO-1	*Super plastic Forming – Super plasticity process, advantages and Properties.*	*Forming of glass fiber- centrifugal spraying, drawing*	*Ion Implantation - Principle, Process & Working*	*Thermal spraying – types*	*Paper Lamination Technology*
	SLO-2	*Diffusion bonding – process – advantages.*	*Strengthening Techniques for Glass*	*A brief outline of Wire Bonding, Packaging, Yield, Reliability*	*Thermal spraying –process- combustion , electrical and cold spraying*	*Laminated object modeling – process*

Learning Resources	
1. *SeropeKalpakjian, "Manufacturing Engineering and Technology", 6th Edition, Addison-Wesley Publishing Co., Boston, 2014.* 2. *Mikell P. Groover "Fundamentals of Modern Manufacturing", 4thEdition, John Wiley & Sons Inc, 2015.*	3. *Helmi A Youssef, Hassan E El-Holfy, Mahmoud H Ahmed, "Manufacturing Technology", CRC Press. 2010*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.N.Vijayakumar, Head Test labs, Mahindra and Mahindra, vijayakumar.n@mahindra.com.	*1. Prof. M.Balasubramanian, Professor, IIT Madras, mbala@iitm.ac.in*	*1 Dr.J.Chandradass,SRMIST, chandraj@srmist.edu.in*
2. Mr.S. Senthil Kumar, Deputy Manager, Renault Nissan Technology & Business Centre India, senthilkumar.subramanian@rntbci.com	*2. Dr.P.Jawahar, Assistant Professor, NIT Agartala, drjawahar.me@nita.ac.in*	*2. Mr.S.Palanisamy,SRMIST, palaniss@srmist.edu.in*



Course Code	18AUE422T	Course Name	COMPUTER INTEGRATED MANUFACTURING	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 :	*Develop capability in students to understand and use CIM in fabrication industry*
CLR-2 :	*Prepare planning and scheduling of process equipment fabrication using various CAPP*
CLR-3 :	*Demonstrate and use automated assembly lines, FMS and Industrial Robots*
CLR-4 :	*Provide basic knowledge in NC and CNC machining*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Discuss the basic components of CIM.*	*1*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*M*	*H*	*L*	*L*	*M*	*H*	*H*	*M*
CLO-2 :	*Enable knowledge in CAPP and MRP.*	*2*	*85*	*80*	*H*	*H*	*H*	*L*	*H*	*L*	*M*	*M*	*M*	*L*	*M*	*H*	*H*	*H*	*L*
CLO-3 :	*Explain about Group Technology and Flexible Manufacturing System*	*2*	*90*	*85*	*H*	*H*	*H*	*M*	*H*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*	*H*	*L*
CLO-4 :	*Equip themselves familiar with AGVs and Robotics*	*2*	*80*	*75*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*M*	*M*	*L*	*H*	*M*	*H*	*H*	*L*
CLO-5 :	*Familiarize with NC and CNC machining*	*2*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	*L*	*M*	*M*	*H*	*L*	*M*	*M*	*H*	*H*	*M*

Duration (hour)		*Introduction To CIM*	*Production Planning And Control And Computerised Process Planning*	*Group Technology and Flexible Manufacturing System*	*Automated Guided Vehicle System /Industrial Robotics*	*NC/CNC Machine Tools*
		9	9	9	9	9
S-1	SLO-1	*Brief introduction to CAD and CAM*	*Process planning – Computer Aided Process Planning (CAPP)*	*Part families*	*Automated Guided Vehicle System (AGVS) AGV System management*	*NC and CNC Technology*
	SLO-2	*Manufacturing Planning, Manufacturing control*				*Types, Classification*
S-2	SLO-1	*Concurrent Engineering*	*Retrieval Computer Aided Process Planning*	*Parts Classification / Parts coding*	*AGVS Application*	*Specification and components*
	SLO-2	*CIM concepts*	*Generative Computer Aided Process Planning*	*Opitz Part Coding system*	*Vehicle Guidance technology*	*Construction Details*
S-3	SLO-1	*Computerized elements of CIM system*	*Aggregate Production Planning*	*Production flow Analysis*	*Vehicle Guidance technology benefits*	*Controllers, Sensors and Actuators,*
	SLO-2	*Types of production*	*Aggregate Plan Strategies*	*Cellular Manufacturing*	*Vehicle Management & Safety*	*CNC hardware*
S-4	SLO-1	*Manufacturing models and Metrics*	*Master Production Schedule*	*Composite part concept*	*Robot Anatomy*	*circulating ball screw*
	SLO-2	*Mathematical models of Production Performance*	*Main Functions of Master Production Scheduling*	*Individual features of Composite part concept*	*Related Attributes*	*anti friction slideways*
S-5	SLO-1	*Model problems I*	*Material Requirement planning*	*Machine cell design and layout*	*Classification of Robots*	*step/servo motors*
	SLO-2	*Model problems II*	*Demand driven MRP*	*Applications of GT*	*Robot Control systems*	*NC/CNC tooling*
S-6	SLO-1	*Marketing engineering*	*Capacity Planning*	*Types of Flexibility*	*End Effectors*	*Fundamentals of Part programming*
	SLO-2	*Problems I*	*Control Systems*	*Flexible Manufacturing System*	*Sensors in Robotics*	*Fundamentals of Part programming*
S-7	SLO-1	*Problems II*	*Shop Floor Control*	*FMS Components*	*Industrial Robot Applications*	*Programming for drilling, lathe and milling machine operations,*
	SLO-2	*Basic Elements of an Automated system*	*Inventory Control*	*FMS Application*	*Material Handling Applications*	*Robot Programming languages*
S-8	SLO-1	*Levels of Automation*	*Introdution on Manufacturing Resource Planning-II (MRP-II)*	*FMS Benefits*	*Process Operations*	*Types of format, Part subroutines, do loops,*

Duration (hour)		*Introduction To CIM*	*Production Planning And Control And Computerised Process Planning*	*Group Technology and Flexible Manufacturing System*	*Automated Guided Vehicle System /Industrial Robotics*	*NC/CNC Machine Tools*
		9	9	9	9	9
	SLO-2	*Five Levels of Automation*	*Enterprise Resource Planning (ERP)*	*FMS Planning*	*Assembly and Inspection*	*Robot Accuracy*
S-9	SLO-1	*Lean Production*	*Problems I*	*FMS Control*	*Robot Programming*	*Canned Cycles, parametric sub routines*
	SLO-2	*Just-In-Time Production*	*Problems II*	*Problems*	*Program*	*Problems*

Learning Resources	
1. *Mikell.P.Groover "Automation, Production Systems and computer integrated manufacturing", 4th edition Pearson Education 2016.* 2. *Kant Vajpayee. S., 'Principles of Computer Integrated Manufacturing', Prentice Hall of India, 2009* 3. *P.Radhakrishnan, Computer Numerical Control Machines and Computer Aided Manufacture, New Age International, 2018*	4. *Mikell.P.Groover and Emory Zimmers Jr., "CAD/CAM", Prentice Hall of India Pvt. Ltd., New Delhi-1, 2008* 5. *P.Radhakrishnan, CNC Machines New Central Agency, 2013* 6. *Yorem Koren, Computer Control of Manufacturing Systems, Mc Graw Hill Education 2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Silambarasan Ramadoss, Renault Nissan Technology & Business Centre India, silambarasan.ramadoss@rntbci.com	*1. Dr. A.Siddharthan, Madras Institute of Technology, sidharth@mitindia.edu*	*1.Dr.J.Chandradass,SRMIST, chandraj@srmist.edu.in*
2. Mr. Prasad Arun Kumar, Mahindra Research Valley, prasad.arunkumar@mahindra.com	*2. Dr. S. Renold Elsen, Vellore Institute of Technology, renoldelsen.s@vit.ac.in*	*2.Mr.S.MadhanKumar,SRMIST, madhanks@srmist.edu.in*

Course Code	18AUE423T	Course Name	PROCESS PLANNING AND COST ESTIMATION	Course Category	E	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:*	Learning		
		1	2	3
CLR-1 :	*Impart basic knowledge about process planning and cost estimation*			
CLR-2 :	*Retrieve the basic idea to estimate different cost*			
CLR-3 :	*Acquaint knowledge to estimate machining time and cost*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Interpreting knowledge about work study and ergonomics.*	*1*	*85*	*80*	*M*	*L*	*L*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-2 :	*Execute the process planning concepts*	*1*	*85*	*80*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-3 :	*Predict various cost estimation*	*2*	*85*	*80*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-4 :	*Calculate the production cost*	*2*	*80*	*75*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-5 :	*Solve machining time and cost*	*3*	*80*	*75*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*

Duration (hour)		Work Study and Ergonomics	Introduction to Process Planning	Cost Estimation	Production Cost Estimation	Estimation of Machining Times & Cost
		9	9	9	9	9
S-1	SLO-1	*Objectives- Work study, Method study*	*Introduction to manufacturing system-Fundamental Concept and Basic Manufacturing process*	*Objectives of cost estimation*	*Estimation of material cost*	*Machine shop operations-Lathe, Drilling*
	SLO-2			*Types of cost estimation*		
S-2	SLO-1	*Basic Procedure for Method Study (Select, Record, Examine, Develop, Define, Install and Maintain)*	*Process planning-Basic concepts, Process selection and analysis*	*Fundamentals of costing and cost accounting methods,*	*Estimation of labor cost*	*Machine shop operations- Milling and Grinding*
	SLO-2					
S-3	SLO-1	*Recording Techniques used in Method Study*	*Details of process plan, process charts and route sheets*	*Components of a Cost Estimate*	*Estimation of Overhead cost*	*Estimation of machining time for basic lathe operation-Turning and Facing*
	SLO-2					
S-4	SLO-1	*Work Measurements, Objectives of work Measurements*	*Process planning methods- manual and computer aided process planning & its approaches*	*Classification of Costing*	*Foundry basics, Methods of casting, Casting tools and accessories*	*Estimation of machining time for Threading and Chamfering*
	SLO-2					
S-5	SLO-1	*Work Sampling, Analytical Estimating*	*Manual process planning-Basic procedure, merits & demerits, applications and comparisons*	*Elements of Cost, Cost of Product*	*Cost estimation in foundry shop-pattern cost, casting cost*	*Estimation of machining time for drilling–sample problems*
	SLO-2					
S-6	SLO-1	*Ergonomics*	*Case study-Preparation of manual process plan for four stroke petrol engine assembly*	*Methods of Cost Estimates*	*Welding, Types of weld joints, Gas welding*	*Estimation of machining time for boring operations –sample problems*
	SLO-2					
S-7	SLO-1	*Ergonomics Principles Applied to Instrument Design and Control*	*Computer aided process planning-Types, Basic procedure, merits, demerits and applications*	*Data Requirements and Sources of information*	*Estimation of Gas welding cost, Gas cutting*	*Estimation of machining time for milling operation-Sample problems*
	SLO-2					
S-8	SLO-1	*Ergonomics Principles Applied to Machines and Controls*	*Process analysis-Break even analysis & It's objectives*	*Types of Cost Estimates, Allowances in Estimation (of Standard Time)*	*Arc welding: Equipments, Cost Estimation*	*Estimation of machining time for Grinding operation-sample problems*
	SLO-2					
S-9	SLO-1	*Ergonomics Principles Applied to Layout of a Work place*	*Statistical process control-Process capability analysis using process control charts*	*Cost Estimation Procedure*	*Cost estimation in Welding shop*	*Case studies: Estimation of cost for a product*
	SLO-2					

Learning Resources	1. *Chitale, A.K., and Gupta, R.C., "Product Design and Manufacturing", Prentice Hall of India, New Delhi, 2011.* 2. *Adithan,M, "Process planning and cost estimation", New Age International(P) Limited,2011*	3. *Nanua Singh, "System Approach to computer Integrated Design and manufacturing", John Wiley & Sons, New York, 1996.* 4. *Sinha.B.P., "Mechanical Estimation and Costing", Tata McGraw-Hill, Publishing Co.,1995* 5. *Narang, G.B.S. and Kumar. "Production and planning", Khana Publishers, New Delhi,1995.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Silambarasan Ramadoss, Renault Nissan Technology & Business Centre India, silambarasan.ramadoss@rntbci.com	*1. Dr. A.Siddharthan, Madras Institute of Technology, sidharth@mitindia.edu*	*1. Dr. J.Chandradass, SRMIST, chandraj@srmist.edu.in*
2.Mr. Prasad Arun Kumar, Mahindra Research Valley, prasad.arunkumar@mahindra.com	*2. Dr. S. Renold Elsen, Vellore Institute of Technology, renoldelsen.s@vit.ac.in*	*2. Mr. M.Palanivendhan, SRMIST, palanivm@srmist.edu.in*

Course Code	18AUE424T	Course Name	AUTOMOTIVE QUALITY 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 :	*Impart the knowledge of quality concepts and quality management systems*
CLR-2 :	*Implement the knowledge of tool and techniques in automotive industries.*
CLR-3 :	*Integrate the idea to work with professional cost accountants to obtain realistic cost estimates*
CLR-4 :	*Collaborate on international quality systems and modern management systems for quality.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Relate the quality concepts and quality production*	*1*	*80*	*75*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-2 :	*Explain quality Management system and different dimensions of quality*	*2*	*85*	*80*	*M*	*H*	*L*	*H*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-3 :	*Implement the application of management tools and techniques for process improvement*	*2*	*85*	*80*	*M*	*H*	*H*	*L*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-4 :	*Assess Automotive TS16949 quality system practices*	*3*	*85*	*80*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*
CLO-5 :	*Validate various system analysis measurement and data collection*	*3*	*90*	*85*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*H*

Duration (hour)		Principles and Practices	Quality Management System	Continuous Process Improvement	Analytical Techniques	Tools and Techniques
		9	9	9	9	9
S-1	SLO-1	*Basic Concepts of Quality. Quality, classification of quality and services*	*Quality Management Systems-Introduction*	*Modern Management Tools and Techniques*	*ISO TS16949 Scope, application and quality management system*	*Quality Tools and Measurement Systems Analysis*
	SLO-2					
S-2	SLO-1	*Quality systems overview*	*Quality Management – A conceptual Frame Work*	*Introduction to Modern Management Techniques*	*Requirements of quality management system*	*Concepts of SPC detection vs. prevention*
	SLO-2					
S-3	SLO-1	*Product Quality design*	*Dimensions of Quality*	*5s concepts*	*Advanced Product Quality Planning (APQP)- Focus and benefits*	*Data collection methods*
	SLO-2					
S-4	SLO-1	*Quality engineering in design of production processes*	*Costs of Quality*	*Kaizen techniques*	*Advanced Product Quality Planning (APQP)- Different Phases*	*Statistical Tools*
	SLO-2					
S-5	SLO-1	*Quality characteristics*	*Quality System Standards*	*Six sigma methodologies*	*Design of Failure Mode Effects Analysis - Types*	*Understanding of measurement systems*
	SLO-2					
S-6	SLO-1	*Reliability*	*ISO 9000 clauses*	*Quality circles*	*Design of Failure Mode Effects Analysis- Advantages and Limitations*	*Variable Gauge R&R*
	SLO-2					
S-7	SLO-1	*Safety*	*ISO 9000 interpretations*	*Taguchi loss function-Theory*	*Process Failure Mode Effects Analysis*	*Introduction to Hypothesis Testing*
	SLO-2					
S-8	SLO-1	*Quality engineering in production*	*ISO TS16949 clauses*	*Taguchi loss function-Applications*	*Production Part Approval Process (PPAP)*	*ANOVA*
	SLO-2					
S-9	SLO-1	*Quality engineering in service*	*ISO TS16949 interpretation*	*POKE –YOKE Techniques*	*Single and Multiple Regression*	*Correlation Analysis*
	SLO-2					

Learning Resources	1. *David Hoyle, "Automotive quality system Handbook" , Butterworth – Heinemann ltd, second edition,oxford,2005* 2. *William M Feld, "Lean Manufacturing: Tools, Techniques and How to Use Them" , APICS, 2010*	3. *Montgomery Douglas C, "Introduction to Statistical Quality Control", John Wiley and Sons, New Delhi, 2009.* 4. *Logo Thetis N, "Managing for Total Quality – From Deming to Taguchi and SPC", Prentice Hall of India Private Limited, New Delhi, 1997.* 5." *Advanced product quality planning and control plan" 2 nd Edition ,Standards media (2008)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Silambarasan Ramadoss, Renault Nissan Technology & Business Centre India, silambarasan.ramadoss@rntbci.com	*1. Dr. A.Siddharthan, Madras Institute of Technology, sidharth@mitindia.edu*	*1. Dr. J.Chandradass, SRMIST, chandraj@srmist.edu.in*
2.Mr. Prasad Arun Kumar, Mahindra Research Valley, prasad.arunkumar@mahindra.com	*2. Dr. S. Renold Elsen, Vellore Institute of Technology, renoldelsen.s@vit.ac.in*	*2. Mr.M.Palanivendhan,SRMIST, palanivm@srmist.edu.in*

Course Code	18AUE425T	Course Name	INDUSTRIAL ENGINEERING AND OPERATIONAL RESEARCH	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Provide an insight into the concepts of industrial engineering and organization*			
CLR-2 :	*Develop a diverse group of professionals and leaders in industrial engineering*			
CLR-3 :	*Enhance the scientific awareness of the society in the field of operation research.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the impact of industrial engineering solutions in a global and social context*	*1*	*85*	*80*	*H*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*H*	*L*	*M*	*L*	*H*	*M*	*H*
CLO-2 :	*Use the knowledge and skills of industrial engineering to model and analyze problems*	*2*	*80*	*75*	*H*	*H*	*M*	*H*	*M*	*M*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*L*	*M*
CLO-3 :	*Investigate Effective utilization of men, equipment and space*	*2*	*85*	*80*	*H*	*M*	*H*	*M*	*H*	*H*	*L*	*H*	*H*	*L*	*H*	*H*	*H*	*M*	*M*
CLO-4 :	*Ensure optimal use of resources with modern technology to create a place of higher learning in the fields of Operation Research*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*M*	*L*
CLO-5 :	*Apply the PERT/CPM for a constraint based problem of service/manufacturing.*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*H*	*M*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*M*

Duration (hour)		Industrial Engineering and Management Science	Production And Productivity	Plant Location and Layout	Work Study	Operational Research
		9	9	9	9	9
S-1	SLO-1	*Introduction to Industrial Engineering, Concepts*	*Production Concept*	*Factors Governing on plant location*	*Definition concept and need for work study*	*Operational Research concept and defination*
	SLO-2					
S-2	SLO-1	*History and Development of Industrial Engineering*	*Production function*	*Locational Economics*	*Method Study*	*Methods of Operational Research*
	SLO-2	*Scientific management*	*Production system*	*Rural V/S Urban plant sites*	*Method Study Procedure*	*Linear Programming*
S-3	SLO-1	*Roles of an Industrial Engineer*	*Analysis of Production system*	*Plant layout*	*Process chart symbols*	*Graphical method*
	SLO-2	*Applications of Industrial Engineer*	*Input output model*	*Principles of Plant layout*	*Flow process charts*	*Model problem in Graphical method*
S-4	SLO-1	*Functions of Industrial Engineering department and its organization*	*Productivity*	*Process layout*	*Process charts types*	*Transportation problem*
	SLO-2	*Production Management*	*Productivity model problem*	*Process layout Merits and demerits*	*Flow diagram*	*Transportation problem types*
S-5	SLO-1	*Production Management Versus Industrial Engineer*	*Factors affecting productivity*	*Product layout*	*Steps in flow diagram*	*Vogels approximate method*
	SLO-2	*Operations Management*	*Product design*	*Product layout Merits and demerits*	*Man type flow process chart*	*Model problem in Vogels approximate method*
S-6	SLO-1	*Management science*	*Increasing productivity of Resources*	*Combination layout*	*String diagram*	*North west corner method*
	SLO-2	*Historical Development*	*Work productivity*	*Fixed position layout*	*String diagram construction*	*Model problem I*
S-7	SLO-1	*Tools of management science*	*Model Problem I*	*Flow pattern layout*	*Multiple Activity chart*	*Cost matrix*
	SLO-2	*Simulation model*	*Model Problem II*	*Flow pattern layout types*	*Multiple Activity chart Construction*	*Profit matrix*
S-8	SLO-1	*Managerial economics*	*Productivity measures*	*Work station*	*Operational analysis*	*Profit matrix with equal supply and demand*

Duration (hour)		Industrial Engineering and Management Science	Production And Productivity	Plant Location and Layout	Work Study	Operational Research
		9	9	9	9	9
	SLO-2	*Managerial Techniques*	*Development of Productivity Measures*	*Work station design*	*Example Operational chart*	*Profit matrix with unequal supply and demand*
S-9	SLO-1	*Managerial Accounting*	*Productivity Measurement system*	*Model Problem I*	*Analysis of motion*	*Degeneracy*
	SLO-2	*Analysis and performance*	*Components of Productivity Measurement system*	*Model Problem II*	*Steps in motion analysis*	*Degeneracy Problem*

Learning Resources	1. *O.P. Khanna, "Industrial Engineering and management", 17th Edition, Dhanpat Rai Publishing Co Pvt Ltd, 2018.* 2. *Martand Telsang, "Industrial Engineering and Production management", 2nd edition, S. Chand publisher, 2014.*	3. *Hamdy A Taha , "Operations Research : An Introduction" 10th Edition, Pearson, 2016.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.N.Vijayakumar, Head Test labs, Mahindra and Mahindra, vijayakumar.n@mahindra.com.	*1. Prof. M.Balasubramanian, Professor, IIT Madras, mbala@iitm.ac.in*	*1.Dr.J.Chandradass,SRMIST, chandraj@srmist.edu.in*
2. Mr.S. Senthil Kumar, Deputy Manager, Renault Nissan Technology & Business Centre India, senthilkumar.subramanian@rntbci.com	*2. Dr.P.Jawahar, Assistant Professor, NIT Agartala, drjawahar.me@nita.ac.in*	*2.Mr.S.MadhanKumar,SRMIST, madhanks@srmist.edu.in*

Course Code	18AUE331T	Course Name	HEAT VENTILATION AND AIR CONDITIONING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18AUC203T	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 working of Refrigeration system
CLR-2 :	Interpret the knowledge on Psychrometry process
CLR-3 :	Understand the refrigerant properties
CLR-4 :	Illustrate the Load calculation
CLR-5 :	Understand the function of air distribution system

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Select the various Refrigeration system	3	90	85	H	M	H	M	L	L	H	M	M	M	L	M	M	M	L
CLO-2 :	Identify the thermal condition of Psychrometry process	1	80	75	H	M	M	M	M	L	M	L	M	M	L	M	M	M	H
CLO-3 :	Distinguish the refrigerant properties	2	85	80	H	M	M	M	M	M	M	L	M	M	M	M	H	M	H
CLO-4 :	Perform the Load calculation	2	85	80	H	H	M	H	M	L	L	L	M	M	L	M	M	M	M
CLO-5 :	Analyze and select the air distribution system	1	90	85	H	M	M	M	M	H	H	H	M	M	L	M	M	M	H

Duration (hour)		Fundamentals of Air Conditioning	Heating and Ventilation	Refrigerant	Automatic Climate and Temperature Control	Diagnosis and Services
		09	09	09	09	09
S-1	SLO-1	Introduction to Air Conditioning System	The car heating system	Working of refrigerant in refrigeration system	Block diagram	Diagnosis based on temperature
	SLO-2	Location of Air Conditioning system In a Car	Heat control - Types	Refrigerants used in automotive systems	Types of sensors and actuators	Diagnosis based on pressure
S-2	SLO-1	Schematic layout of Refrigeration System	Water flow type	Ozone Depletion Potential (ODP)	Control logic electrical wiring diagram	A/C system leak testing
	SLO-2	Refrigeration cycle	Air mix type	Global Warming Potential (GWP)	Manual system	Leak testing procedure
S-3	SLO-1	Terminologies In HVAC: TR, COP	Air distribution – Natural flow ventilator	Desirable properties of refrigerant	Automatic system	UV tracer dye
	SLO-2	EER, SEER	Forced flow ventilator (blower)	Selection of refrigerant	Multiplexing between BCM and PCM	Electronic leak detector (Sniffer)
S-4	SLO-1	Modes of Heat transfer	Air inlet and outlet	Thermodynamic requirements	Control of compressor clutch	Oxygen free nitrogen testing
	SLO-2	Heat Exchanger and Its Types	Fan characteristics	Freezing point	Blower motor	Vacuum testing
S-5	SLO-1	Shell-and-Tube Exchangers	Centrifugal fans	Critical temperature	Different types of sensors	Oil Stains
	SLO-2	Spiral Tube Heat Exchangers	Axial fans	Flammability	Temperature sensor	Servicing of compressor
S-6	SLO-1	Types of Compressors	Air filtration	Toxicity	Sun Load	Servicing of evaporator
	SLO-2	Compressor clutches	Air quality sensing	Action of Refrigerant with water	Pressure sensor – capacitive sensor	Servicing of condenser
S-7	SLO-1	Compressor clutch electrical circuit	Air distribution unit	Action of Refrigerant with oil	Strain gauge sensor	Servicing of heater core
	SLO-2	Compressor lubrication	Air diffuser system	Classification of Refrigerant Mixtures	Pressure sensor using piezoelectricity	Servicing of expansion valve system
S-8	SLO-1	Condenser	Dash HVAC	Ambient conditions affecting system pressures	Angle sensors	System flushing
	SLO-2	Evaporator	Boot HVAC	Containers handling refrigerants	Speed sensor, Inductive type speed sensor	Odour removal
S-9	SLO-1	Receiver	Dual HVAC	Discharging of refrigerant	Humidity sensor	Retrofitting
	SLO-2	Accumulators, Expansion Valve	Booster heating systems	Charging of refrigerant	Air quality sensor	Replacing orifice valve

Learning Resources	1. *Warren Farnell and James D. Halderman, "Automotive Heating Ventilation and Air Conditioning systems", Classroom Manual, Pearson Prentice Hall, 2004* 2. *C. P. Arora "Refrigeration and Air conditioning" – McGraw Hill Education (India) Private Limited, New Delhi,2010* 3. *Roy J. Dossat, "Principles of Refrigeration", 4th edition, Pearson Education Asia, 2009*	4. *William H. Crouse and Donald I. Anglin - "Automotive Air conditioning" - McGraw Hill, 2000* 5. *Paul Weiser - "Automotive Air Conditioning" - Reston Publishing Co., Inc., - 1990* 6. *MacDonald, K.I., "Automotive Air Conditioning" - Theodore Audel series - 1978*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr D Rajasekaran, Freeze India Manufacturing Pvt Limited, rajakd@fim.com	*1. Dr A Baskaran, P. A. College of Engineering and Technology, boss120367@gmail.com*	*1., Dr. S. Thiyagarajan, SRMIST*
2. Mr S Ashok, ETA, ashoks@eta-engg.com	*2. Dr G Venkatesan, Pondicherry Engineering College, rvenkirm@pec.com*	*2. Mr. S. Logeshwaran, SRMIST*

Course Code	18AUE332T	Course Name	ENGINE TESTING AND VALIDATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC301J*	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 :	*Evaluate the working principle of measuring instruments*
CLR-2 :	*Employ various instruments for measuring engine parameters*
CLR-3 :	*Create insight on the fundamental considerations for engine test facility*
CLR-4 :	*Analyze the various engine operating parameters*
CLR-5 :	*Analyze the data acquired from the engine*
CLR-6 :	*Validate the data acquired from the engine*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the knowledge of basic principle of measuring instruments*	1	80	75	H	M	H	M	L	L	M	M	M	M	L	L	H	M	L
CLO-2 :	*Measure the various engine operating parameters of I.C engine*	2	85	80	H	M	M	M	M	L	M	L	M	M	M	M	H	M	L
CLO-3 :	*Develop an engine test rig with necessary instrumentation*	1	80	75	M	H	M	H	M	M	M	M	H	H	M	M	H	M	L
CLO-4 :	*Evaluate the performance parameters in IC engines*	2	80	75	H	M	M	M	H	M	M	M	H	H	M	M	H	M	L
CLO-5 :	*Analyze and validate various engine test results*	2	85	80	H	M	M	M	M	M	M	M	H	M	M	M	H	M	M

Duration (hour)		Instrumentation	Measurements	Test facility layout	Performance parameters	Data analysis
		9	9	9	9	9
S-1	SLO-1	*Instrumentation and data acquisition - Introduction*	*Indicated power measurement*	*Test facility layout considerations- fundamentals*	*Engine performance parameters - Introduction*	*Validation of data and test results - Introduction*
	SLO-2	*Pressure measurement*	*Frictional power measurement*	*Test cell - thermodynamic system*	*Engine performance parameters - Explanation*	*General principles for data validation in engine testing*
S-2	SLO-1	*The Hall-effect sensor*	*Tutorial session*	*Basics of test cell and control room design*	*Brake power*	*Error types*
	SLO-2	*Shielded-field sensor*	*Tutorial session*	*Ventilation and air conditioning*	*Torque Output*	*Error Sources*
S-3	SLO-1	*Crankshaft position sensor*	*Brake power measurements*	*Vibration control*	*Tutorial session*	*Combination of errors*
	SLO-2	*Types*	*Torque and speed measurements*	*Test cell noise control*	*Tutorial session*	*Experiment repeatability*
S-4	SLO-1	*Throttle position sensor*	*Dynamometer - Introduction*	*Cooling circuit requirements*	*Mean effective pressure*	*Instrument sensitivity*
	SLO-2	*Temperature sensors*	*Mechanical Dynamometer*	*Installation*	*Mechanical efficiency*	*Experimental precision*
S-5	SLO-1	*Coolant sensors*	*Electrical Dynamometer*	*Exhaust gas system*	*Tutorial session*	*Absolute and relative accuracy*
	SLO-2	*Sensors for Feedback control*	*Eddy Current Dynamometer*	*Installation*	*Tutorial session*	*Traceability*
S-6	SLO-1	*Exhaust gas oxygen sensor*	*Measurement of speed*	*Electrical system considerations*	*Volumetric efficiency and Fuel-air ratio*	*Uncertainty- calibration –definition, importance*
	SLO-2	*EGO characteristics*	*Fuel consumption measurement*	*Layout*	*Specific fuel consumption*	*Calibration - definition*
S-7	SLO-1	*Switching characteristics*	*Air consumption measurement*	*Fuel storage requirements*	*Tutorial session*	*Calibration - importance*
	SLO-2	*Knock sensor*	*Smoke and particulate measurement*	*Fuel supply requirements*	*Tutorial session*	*Calibration techniques for pressure*
S-8	SLO-1	*Pressure sensor*	*Measurement of exhaust emissions – HC, CO, NOx and CO_2*	*Fuel treatment systems*	*Heat Balance*	*Calibration techniques for temperature*
	SLO-2	*Data Acquisition, Data collection and control systems (EDACS)*	*Tutorial session*	*Input parameters for engine testing*	*Brake thermal efficiency*	*Gaussian distribution as a statistical tool*
S-9	SLO-1	*Post processing of data*	*Tutorial session*	*Maintenance of engine test facility*	*Tutorial session*	*Error analysis*
	SLO-2	*Tutorial session*	*Tutorial session*	*Troubleshooting of engine instruments*	*Tutorial session*	*Tutorial session*

Learning Resources	1. *A.J.Martyr, M.A. Plint, Engine Testing and Theory and Practice,3rd edition,-SAE International, 2007* 2. *Dietrich,C.F. "Uncertainty, Calibration and Probability", Adam Hilger, London.1973*	8. *Jyotindra S. Killedar, Dynamometer: Theory and application to engine testing, Xlibris Corporation LLC, 2012* 9. *A.J.Martyr, M.A. Plint, Engine testing: The design, building, modification and use of powertrain test facilities, 4th edition,- Elsevier, 2012*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.ShanmugaSundaram, Renault Nissan, sankaran@rntbci.com	*1. Dr.V.Karthickeyan, Sri Krishna College of Engineering, karthickeyanv@skcet.ac.in*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr S Ashok, ETA, ashoks@eta-engg.com	*2. Dr.P.Nanthakumar, Amrita School of Engineering, p_nanthakumar@cb.amrita.edu*	*2. Dr. S. Thiyagarajan, SRMIST*

Course Code	18AUE333T	Course Name	FUEL TESTING AND STANDARDS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC301J*	Co-requisite Courses	*NIL*	Progressive Courses	
Course Offering Department	*Automobile Engineering*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Learn the sources, composition and properties of automotive fuels*			
CLR-2 :	*Gain knowledge on reference and commercial fuels and road map to quality improvement*			
CLR-3 :	*Acquire knowledge on the significance of different fuel properties with respect to engine application*			
CLR-4 :	*Understand and become familiar with BIS testing standards for gasoline and diesel*			
CLR-5 :	*Conceive idea on the testing methods for LPG, CNG and biodiesels*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the sources, composition and properties of automotive fuels and significance of testing fuels*	*2*	*80*	*75*	*M*	*M*	*L*	*M*	*L*	*H*	*H*	*H*	*M*	*L*	*L*	*M*	*M*	*H*	*H*
CLO-2 :	*Acquire knowledge on the specification of reference fuels for testing vehicles, road map and bottle necks in quality improvement*	*2*	*80*	*75*	*M*	*M*	*L*	*M*	*L*	*H*	*H*	*H*	*M*	*L*	*L*	*M*	*M*	*H*	*H*
CLO-3 :	*Learn the significant fuel properties and its implication in engine application*	*2*	*80*	*75*	*M*	*M*	*L*	*M*	*L*	*H*	*H*	*H*	*M*	*L*	*L*	*M*	*M*	*H*	*H*
CLO-4 :	*Gain knowledge on commercial gasoline and diesel fuel testing as specified in BIS*	*1*	*80*	*75*	*M*	*M*	*L*	*M*	*L*	*H*	*H*	*H*	*M*	*L*	*L*	*M*	*M*	*H*	*H*
CLO-5 :	*Gain knowledge on CNG, LPG and biodiesel testing*	*1*	*80*	*75*	*M*	*M*	*L*	*M*	*L*	*H*	*H*	*H*	*M*	*L*	*L*	*M*	*M*	*H*	*H*

Duration (hour)		Automotive fuels	Reference and commercial fuels	Fuel Properties	Commercial Gasoline and Diesel fuel testing as specified in BIS	CNG, LPG and Biodiesels testing
		9	9	9	9	9
S-1	SLO1	*Petroleum - sources and composition*	*Technical specification of fuels - significance*	*Properties of different fuels-Volatility*	*Method to determine Distillation temperatures*	*Method to determine methane and Ethane content*
	SLO2	*Gasoline, Diesel- sources and composition*	*Technical Specification of Reference fuel for testing vehicles -Gasoline*	*Properties of different fuels- Oxidation stability*	*Research Octane Number (RON), Motor Octane Number (MON)*	*C_3 and C_4 content*
S-2	SLO1	*CNG- sources and composition*	*Technical Specification of Reference fuel for testing vehicles - Diesel*	*Properties of different fuels- Octane rating*	*Calorific value, Oxidation Stability*	*Motor Octane number*
	SLO2	*LPG –sources and composition*	*Technical Specification of Reference fuel for testing vehicles -CNG*	*Properties of different fuels- Cetane rating*	*Sulphur content*	*Hydrogen sulphide content(LPG)*
S-3	SLO1	*Alcohols –sources and composition*	*Technical Specification of Reference fuel for testing vehicles - LPG*	*Properties of different fuels- Cetane rating*	*Reid Vapour Pressure*	*Odour, Copper strip corrosion*
	SLO2	*Alcohols –sources and composition*	*Technical Specification of Reference fuel for testing vehicles - Blended fuels*	*Calorific Value*	*Benzene, Aromatic*	*Wobbe Index(CNG)*
S-4	SLO1	*Biodiesels –sources and composition*	*Comparison of the specification of Commercial Gasoline and commercial diesel for different Bharat stage norms,*	*Density*	*Olefin and oxygen content*	*Oxidation Stability*

	SLO2	*Biodiesels –sources and composition*	*Comparison of the specification of Commercial Gasoline and commercial diesel for different Bharat stage norms,*	*Viscosity*	*Method to determine Ash content*	*Low temperature flow properties*
S-5	SLO1	*Reformulated fuels -Types and Use*	*Fuel quality improvement accomplished in India*	*Carbon Residue Etc.*	*Carbon residue*	*Kinematic viscosity*
	SLO2	*Reformulated fuels -Types and Use*	*Fuel quality improvement accomplished in India*	*Characteristic requirements of different fuels in IC engines- Availability*	*Cetane number and Index*	*Cetane number, Copper strip corrosion*
S-6	SLO1	*Additives-Types and Use*	*Fuel quality compliance issues*	*Characteristic requirements of different fuels in IC engines- Fuel economy*	*Distillation temperature*	*Ester content, Mono, Di and Tri-glycerides*
	SLO2	*Hydrogen as IC engine fuel*	*Fuel quality compliance issues*	*Characteristic requirements of different fuels in IC engines- Performance*	*Flash point, Kinematic viscosity*	*Density, Iodine Number*
S-7	SLO1	*Comparison of LPG. CNG, Hydrogen*	*Fuel testing*	*Gasoline quality effects on vehicle emissions,*	*Density, calorific value*	*Structure indices*
	SLO2	*Comparison of LPG. CNG, Hydrogen*	*Presumptive liability*	*Diesel quality effects on vehicle emissions*	*Test for sulphur and water content, sulphated ash*	*Liquid chromatography technique*
S-8	SLO1	*Importance of fuel testing*	*Fuel registration and tracking-A comparison in India, USA and Japan*	*Ultra low sulphur fuels*	*Cold filter plug point ,Cloud point*	*Gas chromatography*
	SLO2	*Need for fuel testing Standards*	*Fuel registration and tracking-A comparison in India, USA and Japan*	*Lubricity characteristics*	*Copper strip corrosion*	*Mass Spectrometry analysis*
S-9	SLO1	*An overview of the different standards available for fuel testing-EN, ASTM, ISO, JIS BIS*	*Inhibiting factors in fuel quality improvement in India*	*Flame characteristics- burning velocity,* flame temperature *and flammability limit*	*Oxidative stability*	*Photo spectrometry analysis*
	SLO2	*An overview of the different standards available for fuel testing-EN, ASTM, ISO, JIS BIS*	*Inhibiting factors in fuel quality improvement in India*	*Flame characteristics- burning velocity,* flame temperature *and flammability limit*	*Polycyclic Aromatic Hydrocarbon*	*Photo spectrometry analysis*

Learning Resources	1. *Automotive Fuels Reference Book-Keith Owen, Trevor Coley, Second Edition, Society of Automotive Engineers Inc.,1995* 2. *ALTERNATIVE FUELS Concepts, Technologies and Developments S.S. Thipse, Jaico Publishing House* 3. *Practical Handbook on Fuel Properties and Testing by SajidZaman, Lambert Academic Publishing, 2014.*	4. *Motor Vehicles Act ,2009,India* 5. *ARAI Tap Document –Document on Test Method, Testing Equipments and Related Procedures for Testing Type approval and Conformity of Production (COP),Ministry of Road Transport and High ways* 6. *Biodiesel Production and Properties by AmitSarin, RSC Publishing ,2012*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	40%	-	40%	-	40%	-	40%	-
	Understand										
Level 2	Apply	40%	-	40%	-	40%	-	40%	-	40%	-
	Analyze										
Level 3	Evaluate	20%	-	20%	-	20%	-	20%	-	20%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100%-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.Gunabalan,Manager, R&D Turbo Energy ,Chennai,	*1.Dr.M.Arul Prakasajothi, Associate Professor, Mechanical Engineering, VelTech , Deemed to be university ,Email :arulprakasajothi@veltech.edu.in*	*1. Dr. S. Thiyagarajan. SRMIST*
2. Mr.Shantha Kumar, Lead Engineer, Royal Enfield	*2.Dr.S.Natrajan, Assistant Professor(Senior Grade),Mechanical Engineering, Sri Venkateswara College of Engineering, Email: natraj@svce.ac.in*	*2.Mr. C. Prabhu, SRMIST*

Course Code	18AUE334T	Course Name	AUTOMOTIVE EXHAUST SYSTEM DEVELOPMENT	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC301J*	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:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	*Gain knowledge about Various exhaust systems.*																		
CLR-2 :	*Understand various emission norms and control methods*																		
CLR-3 :	*Gain knowledge about noise pollutions and control methods*																		
CLR-4 :	*Enlighten the knowledge in Computational analysis.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand the History and evolution of Automobile Exhaust System*	*1*	*85*	*80*	*H*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*	*M*
CLO-2 :	*Gain familiarity on the emission norms and emission reduction techniques*	*1*	*85*	*80*	*H*	*H*	*M*	*M*	*L*	*L*	*M*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*M*
CLO-3 :	*Get familiarized with the basics of acoustics, muffler types and characteristic design of mufflers*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*M*	*M*
CLO-4 :	*Understand the procedures and fundamentals involved in computational fluid dynamic, thermal and structural analysis of vehicle exhaust system*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*L*	*H*
CLO-5 :	*Understand the fundamentals involved in testing and validation of automotive exhaust system*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*

Duration (hour)		History of Automobile Exhaust Systems	Hot End	Cold End	Computational Analysis (CFD and FEA)	Testing and Validation
		09	09	09	09	09
S-1	SLO-1	*History and evolution of automobile exhaust system*	*Gasoline engine out pollutants*	*Basics of acoustics, fundamentals of sound, terminologies, noise cancellation.*	*CFD for vehicle exhaust system, governing equation of fluid flow and heat transfer*	*Vehicle noise measurement*
	SLO-2	*History and evolution of automobile exhaust system*	*Diesel engine out pollutants*	*Destructive & constructive interferences*	*CFD for vehicle exhaust system, governing equation of fluid flow and heat transfer*	*Vehicle noise measurement*
S-2	SLO-1	*Basics of exhaust system*	*Emission norms*	*Engine noise introduction, gasoline & diesel engine operation*	*Flow uniformity, pressure loss through exhaust system*	*Operational vibration analysis, experimental modal analysis*
	SLO-2	*Exhaust system from engine head face to tail pipe*	*Converter hot end components*	*Exhaust noise characteristics, vehicle pass by noise, exhaust noise measurement standards*	*Exhaust system, flow eccentricity, hego index, conjugate heat transfer analysis*	*Air leak test, thermal shock tests, thermal fatigue test*
S-3	SLO-1	*Layout of exhaust system*	*Three way catalytic converter, manifold – cone profiles.*	*Types of exhaust noises, pulsation noises, flow noises, booming noises*	*Introduction to finite element analysis*	*Back pressure measurement test*
	SLO-2	*Different components of exhaust system*	*Substrate*	*Shell radiation noises, passive noise reduction techniques*	*Present, past, future features*	*Hot end system*
S-4	SLO-1	*Introduction about air pollution and noise pollution*	*Types of substrate*	*Types of mufflers, reflective, absorptive, hybrid mufflers*	*Introduction to preprocessing 1d, 2d, 3d elements*	*Hot vibration test, cold vibration test*
	SLO-2	*Air pollution and noise control requirements in automobiles*	*Wash coat, mat, types of mats, shell*	*Muffler design constrains, muffler internal design, tri flow muffler, straight through muffler*	*Meshing and processing techniques*	*Flow noise measurement*
S-5	SLO-1	*Hot end components of exhaust system*	*Canning and types of canning*	*Helmholtz resonator, internal resonators*	*Statics of strength of materials*	*Shell deformation test, cold end: biaxial fatigue test*
	SLO-2	*Cold end components of exhaust system*	*Controlled canning, gbd (gab bulk density)*	*Baffle plates, perforations, shells, end plates, pipe diameters*	*Types of analysis*	*Uniaxial fatigue test, salt spray test, condensate water noise test*

Duration (hour)		History of Automobile Exhaust Systems	Hot End	Cold End	Computational Analysis (CFD and FEA)	Testing and Validation
		09	09	09	09	09
S-6	SLO-1	*Manufacturing of exhaust components*	*Temperature sensor, oxygen sensor*	*Absorptive materials, development methodologies, muffler performance parameters, sound transmission loss, insertion loss*	*Modal analysis*	*Transmission loss measurement*
	SLO-2	*Exhaust manifold manufacturing process*	*Thermal management, insulators, heat shields (gasoline \ diesel).*	*Noise reduction, tail pipe noise level, back pressure, vehicle interior noise levels, advanced muffler technologies, cat con integrated muffler*	*Linear static analysis*	*Shell stiffness measurement , glass wool endurance test*
S-7	SLO-1	*Silencer manufacturing process*	*Advancement in substrates, Technology for gasoline engine*	*Variable flow muffler, twin mufflers, active noise cancellation, sporty sound mufflers*	*Introduction to non-linear analysis*	*Resonance frequency measurement*
	SLO-2	*Exhaust system integration*	*Gasoline particulate filter(gpf)*	*Sound engineering, off road, on road, non-road muffler applications examples, manufacturing types & process*	*Dynamic analysis*	*Shell radiation noise measurement*
S-8	SLO-1	*Service of exhaust system*	*Lean NOx trap (INT), Technology for diesel engine*	*Roll and spot welding, lock seaming.*	*Thermal analysis*	*Tail pipe noise measurement*
	SLO-2	*Service of exhaust system*	*Exhaust gas recirculation (EGR)*	*Double seaming, web forming.*	*RLDA & fatigue analysis*	*Tail pipe noise measurement*
S-9	SLO-1	*Replacing of exhaust system*	*Diesel oxidation catalyst (DOC), partial flow filter (PFF), diesel particulate filter (DPF)*	*Clinching, cold metal transfer, hydro forming.*	*Post processing techniques of different analysis*	*Water drainage ability test*
	SLO-2	*Replacing of exhaust system*	*Selective catalytic reduction (SCR), selective catalytic reduction filter (SCRF), global regulations and testing protocols*	*Piercing, stamping, muffler examples.*	*Process flows and targets, case study 1-2-3.*	*Water drainage ability test*

Learning Resources	1. *Philip ii smith and John Morrison "The scientific design of exhaust and intake systems engineering and performance"., 3rd edition, publisher : Bentley (Robert) inc., USA*	2. *Istvan l. Ver and leol.Beranek "Noise and vibration control engineering (principles and applications)"., 2 ndedition 2006, publisher : john wiley& sons inc.* 3. *M.Imunjal "Acoustics of ducts and mufflers with applications to exhaust and ventilation system design"., 2nd edition, publisher : wiley- inter science*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.KrishnamoorthyNallappan, Renault Nissan Technology and Business Centre, krishnamoorthy.nallappan @rntbci.com.	*1. Dr.V GANESH, S Sri Venkateswara College of Engineering , vinaganesh@svce.ac.in*	*1. Dr. S. Thiyagarajan, SRMIST*
2. Mr. Ram Prasanth A, Caterpillar India Pvt Ltd, anjaneyulu_ram_p@cat.com	*2. Dr.Parthasarathy M,Vel Tech RangarajanDr.Sagunthala R&D Institute of Science and Technology, nparthasararhy@veltech.edu.in.*	*2. Mr.D. Boopathi, SRMIST*

Course Code	18AUE335T	Course Name	ENGINE AUXILARY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC301J*	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:*	Learning		
		1	2	3
CLR-1 :	*Impart knowledge about Super charging & Turbocharging their mapping procedure and thermodynamic issues related to their operation.*			
CLR-2 :	*Provide a fundamental knowledge on Engine Thermal Management*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire knowledge about Supercharging and compressor mapping.*	*2*	*90*	*90*	*H*	*H*	*M*	*H*	*L*	*L*	*M*	*L*	*H*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-2 :	*Gain knowledge about Flow maps of supercharging systems.*	*2*	*90*	*90*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-3 :	*Analyze Thermodynamic issues with Turbocharging.*	*2*	*90*	*90*	*H*	*M*	*H*	*H*	*M*	*H*	*L*	*L*	*H*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-4 :	*Understand the Modern design features of exhaust turbocharger features.*	*2*	*90*	*90*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*H*	*M*	*L*	*H*	*M*	*H*	*M*	*H*
CLO-5 :	*Acquire knowledge about Engine thermal management.*	*2*	*90*	*90*	*H*	*H*	*M*	*H*	*L*	*H*	*M*	*L*	*L*	*H*	*M*	*M*	*H*	*M*	*H*

Duration (hour)		Introduction	Super charging and turbo charging	Performance characteristics	Feature characteristics	Heat management
		9	9	9	9	9
S-1	SLO1	*Introduction to super charging*	*Introduction to flow maps of supercharging systems*	*Introduction to thermodynamic issues with turbocharging*	*Introduction to particular features of exhaust turbocharging*	*Charge boosting, exhaust pre-release, turbo-cooling*
	SLO2	*Introduction to compressor mapping*	*Two stroke engines*	*Cylinder release temperature*	*Exhaust manifold arrangements for various firing sequences of engines.*	*miller, two stage, complex, hyper-bar, rotor designs*
S-2	SLO1	*Definitions, survey of supercharging methods,*	*Four stroke engines*	*Mean exhaust temperature*	*Exhaust manifold arrangements for various firing sequences of engines.*	*Types of impellers, bearing arrangements,*
	SLO2	*Petrol engines*	*Interaction between turbocharger and engine.*	*Theoretical aspects of complete extraction of work*	*Constant pressure vs pulse turbocharging*	*types and lubrication on bearings*
S-3	SLO1	*Diesel engines*	*Mechanical supercharging,*	*Expanding from release pressure to ambient pressure*	*Constant pressure vs pulse turbocharging.*	*Examples of supercharged engines of road vehicles (cases),*
	SLO2	*Exhaust turbo charging.*	*Mechanical supercharging,*	*Complete conversion into kinetic energy at ambient pressure.*	*Modified forms of pulse turbocharging.*	*introduction to engine cooling systems, engine coolants,*
S-4	SLO1	*Fundamentals of compressor matching,*	*Exhaust turbo charging*	*Complete conversion into kinetic energy at ambient pressure.*	*Transient response.*	*Heat exchangers, in-vehicle installation, performance curves.*
	SLO2	*compressor power*	*Exhaust turbo charging -operational differences.*	*Compressor power in terms of mean piston pressure*	*Transient response*	*Pressurized engine cooling systems: filling, de- aeration & drawdown accessories.*
S-5	SLO1	*Air consumption*	*Equivalent nozzle area of turbine*	*Compressor power in terms of mean piston pressure*	*Torque characteristics of engines with exhaust turbochargers*	*On-highway cooling system test code, engine cooling systems field test (air-to-boil)*
	SLO2	*Types of compressors*	*Equivalent nozzle area of turbine*	*Numerical -compressor power in terms of mean piston pressure*	*Torque characteristics of engines with exhaust turbochargers.*	*Heat exchanger thermal & pressure cycle durability. Cooling fans*

Duration (hour)		Introduction	Super charging and turbo charging	Performance characteristics	Feature characteristics	Heat management
		9	9	9	9	9
S-6	SLO1	*Compressor characteristics*	*Pulse turbocharging*	*Numerical problem -compressor power in terms of mean piston pressure*	*Measures to improve acceleration*	*Fan laws, fan characteristics, and system resistance curve*
	SLO2	*Relationship between air consumption and power*	*Pulse turbocharging*	*Difference in fuel consumption between mechanical and exhaust superchargers.*	*Measures to improve acceleration*	*Cooling flow measurement techniques.*
S-7	SLO1	*Numerical problems-calculate air consumption and power*	*Diagram for determination of operating condition of a single stage turbocharger system.*	*Difference in fuel consumption between mechanical and exhaust superchargers.*	*Measures to improve torque characteristics of exhaust turbocharged engines.*	*Cooling system inspection, trouble diagnosis & service.*
	SLO2	*Numerical problems- calculate air consumption and power*	*Diagram for determination of operating condition of a single stage turbocharger system.*	*Effect of cooling the charge air.*	*Measures to improve torque characteristics of exhaust turbocharged engines.*	*Radiator field failures. Introduction to EGR (exhaust gas recirculation) coolers*
S-8	SLO1	*Volumetric efficiency of supercharged four stroke engines.*	*Examples of computed results*	*Effect of cooling the charge air.*	*Altitude de-rating*	*its significance in reduction of vehicle emissions.*
	SLO2	*Numerical problems-calculate volumetric efficiency*	*Examples of computed results*	*Exhaust turbocharger as a means to increase efficiency*	*Altitude de-rating*	*Cycle test-I*
S-9	SLO1	*Computations of gas exchange process*	*Examples of computed results*	*Numerical problem-Exhaust turbocharger as a means to increase efficiency.*	*Effect of supercharging on exhaust emissions of SI engines*	*Cycle test-II*
	SLO2	*Computations of gas exchange process*	*Tutorials onsupercharging systems*	*Numerical problem-Exhaust turbocharger as a means to increase efficiency.*	*Effect of supercharging on exhaust emissions of CI engines*	*Surprise test*

Learning Resources	1. *Zinner, K, "Auxillary Engine Systems by Supercharging of Internal Combustion Engines"., Springer, 1978.* 2. *N. Watson and M.S. Janota, "Turbocharging the Internal Combustion Engines", Macmillan Press, London 1982* 3. *BOSCH, "Automotive Handbook", 8 th Edition, Bentley Robert Incorporated, 2011* 4. *Lilly, L.C.R, "Diesel Engine Reference Book", Butterworths, London, 1984*	5. *Benson, R.S, Whitehouse N.D, "Internal Combustion Engines", Vol 1 and 2, Pergamon Press Ltd. Oxford UK.1980* 6. *Tom Birch, "Automotive Heating & Air Conditioning", 6th edition, Prentice Hall PTR, 2011* 7. *Hermann Hiereth, Peter Prenninger, "Charging the Internal Combustion Engine", Springer, 2010.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.Jayaraman.R,BLG Logistics,jayaraman.r@blgparekh.com*	1. *Dr.S. Ramkumar, Vel Tech, drsramkumar@veltech.edu*	1. *Dr. V. Edwin Geo, SRMIST*
2. *Mr. ShanmugaSundaram, Renault Nissan, sankaran@rntbci.com*	2. *Mr.R. Sakthivel, Sri Venkateswara College of Engineering, rsakthivel@svce.ac.in*	2. *Mr. T.Prakash, SRMIST*

Course Code	18AUE431T	Course Name	DESIGN OF AUTOMOTIVE THERMAL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC203T*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes/Standards		*Psychometric chart, Heat and Mass transfer data book, Refrigerant table*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	*Understand various thermal systems and its functions*																		
CLR-2 :	*Solve cooling load calculations and to select different types of fans.*																		
CLR-3 :	*Understand various types of compressors*																		
CLR-4 :	*Familiarize with the applications of different fluid systems.*																		
CLR-5 :	*Understand the concepts to design heat exchangers*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand the methodology of a thermal system.*	*1*	*90*	*85*	*H*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*H*	*H*	*H*
CLO-2 :	*Analyze a refrigeration problem to carryout necessary calculation*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*L*	*L*	*H*	*M*	*M*	*M*
CLO-3 :	*Identify different air compressor systems and its applications and able to calculate its efficiencies*	*1*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*H*	*M*	*M*	*M*
CLO-4 :	*List the basic components and analyze the working of fluid transport system*	*2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*H*	*M*
CLO-5 :	*Able to identify parts of heat exchanger systems and design heat exchangers based on various criteria's*	*2*	*90*	*85*	*H*	*M*	*H*	*H*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*H*	*M*	*M*	*H*
CLO-6 :	*Apply the design concepts of automotive thermal systems*	*2*	*90*	*85*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*H*	*H*	*H*

Duration (hour)		*Thermal Systems*	*Automotive Air Conditioning*	*Automotive Air Compressors*	*Fluid Transport*	*Heat Exchangers*
		6	10	10	10	9
S-1	SLO-1	*Introduction to Thermal Systems*	*Introduction to Automotive Air Conditioning*	*Introduction to Air Compressors*	*Introduction to Fluid Transport*	*Introduction to Heat Exchangers*
	SLO-2	*Introduction to Thermal Systems*	*Introduction to Automotive Air Conditioning*	*Introduction to Air Compressors*	*Introduction to Fluid Transport*	*Introduction to Heat Exchangers*
S-2	SLO-1	*System, boundary and surroundings, heat transfer, fluid flow*	*Psychrometric properties*	*Types and classification of compressors*	*Incompressibility and expansion of fluids*	*Functions of radiator, compressor*
	SLO-2	*System, boundary and surroundings, heat transfer, fluid flow*	*Psychrometric properties*	*Types and classification of compressors*	*Incompressibility and expansion of fluids*	*Functions of radiator, compressor*
S-3	SLO-1	*Heat engines – Functions, components, working*	*Use of psychrometric chart*	*Working principle*	*Transmission of forces through fluids, multiplication of forces Fluid power*	*Functions of condenser, evaporator, expansion valve*
	SLO-2	*Heat engines – Functions, components, working*	*Use of psychrometric chart*	*Working principle*	*Transmission of forces through fluids, multiplication of forces Fluid power*	*Functions of condenser, evaporator, expansion valve*
S-4	SLO-1	*Cooling , properties of coolant*	*Refrigerants – Types of refrigerants*	*Reciprocating compressors*	*Applications of fluid power – power brakes, power steering, shock absorber*	*Classification of heat exchangers – According to transfer process*
	SLO-2	*Cooling , properties of coolant*	*Refrigerants – Types of refrigerants*	*Reciprocating compressors*	*Applications of fluid power – power brakes, power steering, shock absorber*	*Classification of heat exchangers – According to transfer process*
S-5	SLO-1	*Coolant recirculation systems*	*Properties and Selection of refrigerants*	*Single and multistage compressors*	*Components of hydraulic and pneumatic systems*	*Number of fluids, surface compactness*
	SLO-2	*Coolant recirculation systems*	*Properties and Selection of refrigerants*	*Single and multistage compressors*	*Components of hydraulic and pneumatic systems*	*Number of fluids, surface compactness*
S-6	SLO-1	*Coolant lubrication systems*	*Factors affecting the air flow*	*Compressors - compression with and without clearance*	*Reservoir, pumps, strainers, filters, valve types, actuators, motors*	*Construction features, flow arrangements, heat transfer mechanisms.*

	SLO-2	*Coolant lubrication systems*	*Factors affecting the air flow*	*Compressors - compression with and without clearance*	*Reservoir, pumps, strainers, filters, valve types, actuators, motors*	*Construction features, flow arrangements, heat transfer mechanisms.*
S-7	SLO-1		*Types of fans*	*Calculations - volumetric, isothermal and isentropic efficiency*	*Accumulators, oil coolers, cooling fan, tubing, piping, hose*	*Selection and design of heat exchangers based on – Types, heat transfer rate*
	SLO-2		*Types of fans*	*Calculations - volumetric, isothermal and isentropic efficiency*	*Accumulators, oil coolers, cooling fan, tubing, piping, hose*	*Selection and design of heat exchangers based on – Types, heat transfer rate*
S-8	SLO-1		*Axial and Centrifugal fans*	*Rotary compressors*	*Fluid transport and power systems*	*Selection and design of heat exchangers based on – cost, pumping power*
	SLO-2		*Axial and Centrifugal fans*	*Rotary compressors*	*Fluid transport and power systems*	*Selection and design of heat exchangers based on – cost, pumping power*
S-9	SLO-1		*Load calculations*	*Comparison between reciprocating and rotary compressors*	*Applications of pneumatic and hydraulic systems*	*Selection and design of heat exchangers based on – size and weight materials*
	SLO-2		*Load calculations*	*Comparison between reciprocating and rotary compressors*	*Applications of pneumatic and hydraulic systems*	*Selection and design of heat exchangers based on – size and weight materials*
S-10	SLO-1		*Winter air conditioning*	*Comparison between centrifugal and axial compressors*	*Advantage and disadvantages of hydraulic systems*	
	SLO-2		*Winter air conditioning*	*Comparison between centrifugal and axial compressors*	*Advantage and disadvantages of hydraulic systems*	

Learning Resources	*1. Rajput R.K, "Thermal Engineering", Laxmi Publications, 8th Edition, New Delhi, 2010* *2. R. C. Sachdeva, "Fundamentals of Engineering Heat and Mass Transfer", New Age Science Ltd., NewDelhi, 2009* *3. C.P Arora "Refrigeration and Air conditioning", 3rd edition., McGraw Hill Education (india) privateLimited.2014*	*4. Holman, J P, "Heat transfer", McGraw – Hill, New york, 1968* *5. Yunus A Cengel, Afshin J Ghajar, "Heat and Mass Transfer"., Tat McGraw Hill Education Private Limited,New Delhi,2013* *6. Andrew parr, "Hydraulics and Pneumatics"., second edition, Butterworth Heinemann*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.ShanmugaSundaram, Renault Nissan, sankaran@rntbci.com	*1. Dr.S. Premnath, Sri Venkateswara College if Engineering, prem@svce.ac.in*	*1. Dr. S. Thiyagarajan, SRMIST*
2. Mr.Jayaraman.R,BLG Logistics,jayaraman.r@blgparekh.com	*2. Dr.V. Karthickeyan, Sri Krishna College of Engineering and Technology, karthickeyanv@skcet.ac.in*	*2. Dr. A. Prabu, SRMIST*

Course Code	18AUE432T	Course Name	SIMULATION OF INTERNAL COMBUSTION ENGINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC301J*	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 Knowledge about various engine design parameters.*
CLR-2 :	*Understand engine numerical modeling.*
CLR-3 :	*Enlighten the knowledge about simulation of various performance parameters for different type engine.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the Various Combustion Parameters.*	*1*	*90*	*85*	*H*	*H*	*M*	*H*	*H*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*M*
CLO-2 :	*Analyze the various idle cycles*	*1*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*
CLO-3 :	*Understand Various Combustion Simulations*	*2*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	*L*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*M*
CLO-4 :	*Gain knowledge about two Stroke engine simulations*	*2*	*90*	*85*	*H*	*M*	*L*	*M*	*H*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*M*
CLO-5 :	*Understand Diesel engine numerical modeling*	*2*	*90*	*85*	*H*	*H*	*L*	*M*	*H*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*M*

Duration (hour)		Introduction to Combustion	SI Engine Simulation With Air as Working Medium	Progressive Combustion	Simulation of 2-Stroke SI Engine	Diesel Engine Simulation
		9	9	9	9	9
S-1	SLO-1	*Introduction to combustion*	*Ideal Cycles in SI Engine*	*SI Engines Simulation With Progressive Combustion*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
	SLO-2	*Heat of reaction*	*Ideal Cycles in SI Engine*	*SI Engines Simulation With Progressive Combustion*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
S-2	SLO-1	*Measurement of URP*	*Actual working cycle in SI Engine*	*SI Engines Simulation With Gas Exchange*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
	SLO-2	*Measurement of URP*	*Actual working cycle in SI Engine*	*SI Engines Simulation With Gas Exchange*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
S-3	SLO-1	*Measurement of HRP*	*Deviation Between Actual And Ideal Cycle – Problems*	*Heat Transfer Process*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
	SLO-2	*Measurement of HRP*	*Deviation Between Actual And Ideal Cycle – Problems*	*Heat Transfer Process*	*Simulate The Performance Of 2 Stroke SI Engine*	*Multi Zone Model For Diesel Combustion*
S-4	SLO-1	*Adiabatic flame temperature*	*SI Engine Simulation With Adiabatic Combustion*	*Friction Calculation*	*Simulate The Performance Of 2 Stroke SI Engine*	*Different Heat Transfer Models For Diesel Engine Simulation*
	SLO-2	*Adiabatic flame temperature*	*SI Engine Simulation With Adiabatic Combustion*	*Friction Calculation*	*Simulate The Performance Of 2 Stroke SI Engine*	*Different Heat Transfer Models For Diesel Engine Simulation*
S-5	SLO-1	*Complete combustion in C/H/O/N Systems*	*SI Engine Temperature Drop Due To Fuel Vaporization*	*Compression Of Simulated Values*	*Simulate The Performance Of 2 Stroke SI Engine*	*Different Heat Transfer Models For Diesel Engine Simulation*
	SLO-2	*Complete combustion in C/H/O/N Systems*	*SI Engine Temperature Drop Due To Fuel Vaporization*	*Compression Of Simulated Values*	*Simulate The Performance Of 2 Stroke SI Engine*	*Different Heat Transfer Models For Diesel Engine Simulation*

Duration (hour)		Introduction to Combustion	SI Engine Simulation With Air as Working Medium	Progressive Combustion	Simulation of 2-Stroke SI Engine	Diesel Engine Simulation
		9	9	9	9	9
S-6	SLO-1	*Constant volume adiabatic combustion*	*Full Throttle Operation - Efficiency Calculation*	*Validation Of The Computer Code*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Equilibrium Calculations*
	SLO-2	*Constant volume adiabatic combustion*	*Full Throttle Operation - Efficiency Calculation*	*Validation Of The Computer Code*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Equilibrium Calculations*
S-7	SLO-1	*Constant pressure adiabatic combustion*	*SI Engine Part-Throttle Operation*	*Engine Performance Simulation*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Equilibrium Calculations*
	SLO-2	*Constant pressure adiabatic combustion*	*SI Engine Part-Throttle Operation*	*Engine Performance Simulation*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Equilibrium Calculations*
S-8	SLO-1	*Calculation of adiabatic flame temperature*	*SI Engine Part-Throttle Efficiency Calculation*	*Pressure Crank Angle Diagram*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Simulation Of Diesel Engine Performance*
	SLO-2	*Calculation of adiabatic flame temperature*	*SI Engine Part-Throttle Efficiency Calculation*	*Pressure Crank Angle Diagram*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Simulation Of Diesel Engine Performance*
S-9	SLO-1	*Isentropic changes of state*	*Super Charged Operation*	*Other Engine Performance*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Simulation For Pollution Estimation*
	SLO-2	*Isentropic changes of state*	*Super Charged Operation*	*Other Engine Performance*	*Simulation Of Unbalanced Forces On Two Stroke Engine*	*Diesel Engine Simulation For Pollution Estimation*

Learning Resources	
1. *Ganesan. V. "Computer Simulation of spark ignition engine process"., Universities Press (I) Ltd, Hyderabad, 1996.* 2. *Ganesan.V, "Computer Simulation of Compression Ignition Engines"., Orient Longman, 2000*	3. *Ramoss. A. L, "Modelling of Internal Combustion Engines Processes"., McGraw Hill Publishing Co., 1992* 4. *Ashley Campbel, "Thermodynamic Analysis of Combustion Engines"., John Wiley & Sons, New York, 1986*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.KrishnamoorthyNallappan, Renault Nissan Technology and Business Centre, krishnamoorthy.nallappan @rntbci.com	*1. Dr.J.Venkatesan, S Sri Venkateswara College of Engineering, jvenkat@svce.ac.in*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr.P.MohamedAzarudeen,Renault Nissan Technology and Business Centre, mohamedazarudeen.pakkirmohideen@rntbci.com	*2. Dr.S.RamKumar, Vel Tech RangarajanDr.Sagunthala R&D Institute of Science and Technology , drsramkumar@veltech.edu.in*	*2. Mr. D. Boopathi, SRMIST*

Course Code	18AUE433T	Course Name	AUTOMOTIVE EMISSION FORMATION AND CONTROLS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC301J*	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Learn about SI engine emission formation*			
CLR-2 :	*Provide an insight CI engine emission formation*			
CLR-3 :	*Familiarize with the basics of noise pollution*			
CLR-4 :	*Create insight on emission measuring instruments*			
CLR-5 :	*Learn about noise and vibration measurement*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Comprehend the various emissions from SI engine and its control techniques*	*1*	*80*	*75*	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*M*	*H*	*H*	*M*	*H*	*H*	*M*
CLO-2 :	*Match the emission reduction techniques from CI engine*	*1*	*85*	*80*	*H*	*M*	*M*	*H*	*M*	*M*	*H*	*M*	*L*	*M*	*H*	*M*	*H*	*H*	*M*
CLO-3 :	*Evaluate the noise pollution formation*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*M*	*L*	*H*	*M*	*M*	*M*	*L*	*H*	*M*	*M*
CLO-4 :	*Apply the knowledge on measuring emissions through instruments*	*2*	*80*	*75*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*L*	*H*	*M*	*H*	*H*	*M*	*L*
CLO-5 :	*Cognize the noise and vibration measurement*	*1*	*85*	*80*	*M*	*H*	*H*	*M*	*H*	*M*	*L*	*H*	*M*	*H*	*M*	*L*	*H*	*M*	*L*

Duration (hour)		SI engine emission	CI engine emission	Noise Pollution	Emission Measurement	Noise measurement
		9	9	9	9	9
S-1	SLO-1	*Emission formation in SI engines (CO, HC)*	*Emission formation in CI engines (HC, CO)*	*Basics of acoustics–fundamentals of sound – terminologies–*	*Principle of operation of emission measuring instruments used in SI and CI engines.*	*Vehicle noise measurement*
	SLO-2	*Emission formation in SI engines (CO, HC)*	*Emission formation in CI engines (HC, CO)*	*Noise cancellation– destructive & constructive interferences*	*Principle of operation of emission measuring instruments used in SI and CI engines.*	*Operational vibration analysis*
S-2	SLO-1	*Emission formation in SI engines (NOx).*	*Emission formation in CI engines (NOx, aldehydes)*	*Engine noise introduction–gasoline & diesel engine operation.*	*Measurement of CO2 and CO by NDIR*	*Experimental modal analysis – air leak test*
	SLO-2	*Emission formation in SI engines (NOx).*	*Emission formation in CI engines (NOx, aldehydes)*	*Exhaust noise characteristics –vehicle pass by noise – exhaust noise measurement standards*	*Measurement of CO2 and CO by NDIR*	*Experimental modal analysis – air leak test*
S-3	SLO-1	*Effect of design variables on emission formation in SI engines*	*Emission formation in CI engines (smoke and particulates)*	*Types of exhaust noises– pulsation noises–flow noises–booming noises*	*Hydrocarbon emission by FID*	*Thermal shock tests – thermal fatigue test*
	SLO-2	*Effect of design variables on emission formation in SI engines*	*Emission formation in CI engines (smoke and particulates)*	*Shell radiation noises–passive noise reduction techniques*	*Hydrocarbon emission by FID*	*Thermal shock tests – thermal fatigue test*
S-4	SLO-1	*Effect of operating variables on emission formation in SI engines*	*Effect of design variables on emission formation in CI engines*	*Types of mufflers –reflective–absorptive –hybrid mufflers –muffler design constrains*	*Chemiluminescentanalyser for NOx*	*Back pressure measurement test–hot end system*
	SLO-2	*Effect of operating variables on emission formation in SI engines*	*Effect of design variables on emission formation in CI engines*	*Muffler internal design–tri flow muffler –straight though muffler*	*Chemiluminescentanalyser for NOx*	*Back pressure measurement test–hot end system*
S-5	SLO-1	*Control techniques -Thermal reactor,*	*Effect of operating variables on emission formation in CI engines*	*Helmholtz resonator – internal resonators –baffle plates– perforations*	*Gas Chromatograph*	*Hot vibration test – cold vibration test*
	SLO-2	*Control techniques -Thermal reactor,*	*Effect of operating variables on emission formation in CI engines*	*shells –end plates–pipe diameters*	*Gas Chromatograph*	*flow noise measurement*

Duration (hour)		SI engine emission	CI engine emission	Noise Pollution	Emission Measurement	Noise measurement
		9	9	9	9	9
S-6	SLO-1	*Control techniques - exhaust gas recirculation*	*Control techniques, exhaust gas recirculation*	*Absorptive materials –development methodologies*	*Spot sampling*	*Salt spray test – condensate water noise test*
	SLO-2	*Control techniques - exhaust gas recirculation*	*Control techniques, exhaust gas recirculation*	*muffler performance parameters– sound transmission loss –insertion loss*	*Spot sampling*	*Salt spray test – condensate water noise test*
S-7	SLO-1	*Three way catalytic convertor*	*NOx selective catalytic reduction*	*Noise reduction–tail pipe noise level –back pressure –vehicle interior noise levels*	*Continuous indication type smoke meters (Bosch, AVL and Hartridge smoke meters)*	*Transmission loss measurement – shell stiffness measurement – glass wool endurance test*
	SLO-2	*Three way catalytic convertor*	*NOx selective catalytic reduction*	*Advanced muffler technologies–cat con integrated muffler*	*Continuous indication type smoke meters (Bosch, AVL and Hartridge smoke meters)*	*Transmission loss measurement – shell stiffness measurement – glass wool endurance test*
S-8	SLO-1	*Charcoal canister control for evaporative emission*	*Diesel oxidation catalyst catalytic convertor*	*Variable flow muffler –twin mufflers–active noise cancellation–sporty sound mufflers–sound engineering*	*Emission test procedures – FTP*	*Resonance frequency measurement – shell radiation noise measurement*
	SLO-2	*Charcoal canister control for evaporative emission*	*Diesel oxidation catalyst catalytic convertor*	*Off road – on road –non road muffler applications examples –manufacturing types & process*	*Emission test procedures – FTP*	*Resonance frequency measurement – shell radiation noise measurement*
S-9	SLO-1	*Positive crank case ventilation for blow by gas control*	*Diesel particulate filter*	*Roll and spot welding–lock seaming–double seaming –web forming–clinching–cold metal transfer*	*Euro and Bharat norms*	*Tail pipe noise measurement – water drainage ability test.*
	SLO-2	*Positive crank case ventilation for blow by gas control*	*NOx versus particulates –trade off*	*Hydro forming –piercing– stamping–muffler examples*	*Euro and Bharat norms*	*Tail pipe noise measurement – water drainage ability test.*

Learning Resources	1. *Ganesan V, "Internal combustion engines"., 4th edition, Tata McGraw Hill Education, 2012*	2. *John B Heywood. "Internal Combustion Engine Fundamentals". , Tata McGraw-Hill 1988.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.SarathRamakannan, Aston Martin, sharath.ramakrishnan@astonmartin.com	*1. Dr. N. Balaji, Sri Krishna College of Engineering, balajin@skcet.ac.in*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr.ShanmugaSundaram, Renault Nissan, sankaran@rntbci.com	*2. Dr.R.Sakthivel, Sri Venkateswara College of Engineering, rsakthivel@svce.ac.in*	*2. Dr. S. Thiyagarajan, SRMIST*

Course Code	18AUE434T	Course Name	ALTERNATIVE FUELS AND ENERGY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC301J*	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 :	*Evaluate the use of alcohol in SI and CI engine*
CLR-2 :	*Create insight on use of vegetable oil as fuel in CI engine*
CLR-3 :	*Evaluate the use of hydrogen as fuel in SI and CI engine*
CLR-4 :	*Analyze the other gaseous fuels utilization in SI and CI engine*
CLR-5 :	*Create insight on hybrid, solar and electric based vehicles*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the knowledge of using alcohol as fuel*	*1*	*90*	*85*	*H*	*L*	*L*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*L*	*H*	*H*	*M*	*L*
CLO-2 :	*List the techniques employed to use vegetable oil in CI engine*	*1*	*90*	*85*	*H*	*L*	*L*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*L*	*H*	*H*	*M*	*L*
CLO-3 :	*Develop system for using hydrogen in engines*	*2*	*90*	*85*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*L*	*M*	*M*	*L*	*H*	*H*	*M*	*M*
CLO-4 :	*Understand the concepts of biogas, LPG and CNG as fuels in IC engines*	*1*	*90*	*85*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*L*	*H*	*M*	*H*	*L*
CLO-5 :	*Demonstrate the working of hybrid, solar and electric vehicles*	*2*	*90*	*85*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*L*	*H*	*M*	*M*	*M*

Duration (hour)		Alcohol Fuels	Vegetable Oil	Hydrogen based fuels	Other Gaseous Fuels	Hybrid, solar and Electric vehicles
		9	9	9	9	9
S-1	SLO-1	*Need for Alternate Fuel*	*Various vegetable oils and its properties*	*Hydrogen as fuel in IC engine, hydrogen properties*	*Biogas – Introduction, sources*	*Layout of Electric vehicles, Advantages and limitations*
	SLO-2	*Need for Alternate Fuel*	*Various vegetable oils and its properties*	*Hydrogen as fuel in IC engine, hydrogen properties*	*Biogas – Introduction, sources*	*Layout of Electric vehicles, Advantages and limitations*
S-2	SLO-1	*Properties of alcohol as IC engine fuel*	*Problems of using vegetable oil in CI engine and techniques to overcome*	*Hydrogen production and storage*	*Biogas production*	*System components, Electronic controlled system*
	SLO-2	*Properties of alcohol as IC engine fuel*	*Problems of using vegetable oil in CI engine and techniques to overcome*	*Hydrogen production and storage*	*Biogas production*	*System components, Electronic controlled system*
S-3	SLO-1	*Alcohol use in SI engine – Performance and emission*	*Trans-esterification – Reaction, Process optimization, fuel property variations*	*Problems associated with hydrogen as fuel and its solution*	*Factors affecting biogas production*	*High energy and power density batteries*
	SLO-2	*Alcohol use in SI engine – Performance and emission*	*Trans-esterification – Reaction, Process optimization, fuel property variations*	*Problems associated with hydrogen as fuel and its solution*	*Factors affecting biogas production*	*High energy and power density batteries*
S-4	SLO-1	*Gasohol, Flexible Fuel system, Reformed Alcohol*	*Blending – Diesel, ether based fuels*	*Different methods of using hydrogen in SI and CI engine*	*Biogas usage in CI and SI engine*	*Types of hybrid vehicles*
	SLO-2	*Gasohol, Flexible Fuel system, Reformed Alcohol*	*Blending – Diesel, ether based fuels*	*Different methods of using hydrogen in SI and CI engine*	*Biogas usage in CI and SI engine*	*Types of hybrid vehicles*
S-5	SLO-1	*Alcohol use in SI engine – Performance and emission*	*Fuel Preheating – electric based and waste exhaust heat , emulsification*	*Performance, emission and combustion characteristics*	*Properties of LPG and CNG as fuel in IC engine*	*Hybrid vehicle configuration*
	SLO-2	*Alcohol use in SI engine – Performance and emission*	*Fuel Preheating – electric based and waste exhaust heat , emulsification*	*Performance, emission and combustion characteristics*	*Properties of LPG and CNG as fuel in IC engine*	*Hybrid vehicle configuration*
S-6	SLO-1	*Dual fuel combustion*	*Waste to energy – Waste plastic and tires to fuel*	*Liquid hydrogen and metal hydrides for cars*	*Fuel metering system*	*Solar cell for energy collection*

	SLO-2	*Dual fuel combustion*	*Waste to energy – Waste plastic and tires to fuel*	*Liquid hydrogen and metal hydrides for cars*	*Fuel metering system*	*Solar cell for energy collection*
S-7	SLO-1	*Spark assisted diesel engine*	*Various techniques for conversion of waste solid to fuel*	*Fuel cell : Concept with hydrogen and methanol*	*Combustion characteristics*	*Storage batteries*
	SLO-2	*Spark assisted diesel engine*	*Various techniques for conversion of waste solid to fuel*	*Fuel cell : Concept with hydrogen and methanol*	*Combustion characteristics*	*Storage batteries*
S-8	SLO-1	*Surface ignition, ignition accelerators*	*Performance and emission comparison of vegetable oil and biodiesel*	*Power rating, performance and heat dissipation*	*Effect on performance and emission characteristics*	*Layout of solar powered vehicles*
	SLO-2	*Surface ignition, ignition accelerators*	*Performance and emission comparison of vegetable oil and biodiesel*	*Power rating, performance and heat dissipation*	*Effect on performance and emission characteristics*	*Layout of solar powered vehicles*
S-9	SLO-1	*Alcohol production techniques*	*First to fifth generation biofuels*	*Layout of fuel cell vehicle*	*LPG and CNG vehicle layout*	*Advantages and limitations*
	SLO-2	*Alcohol production techniques*	*First to fifth generation biofuels*	*Layout of fuel cell vehicle*	*LPG and CNG vehicle layout*	*Advantages and limitations*

Learning Resources	1. *M.K. GajendraBabu &K.A. Subramanian, Alternate Transportation Fuels: Utilization in combustion engine, CRC press, 2017*	2. *Richard L.Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. S. Sivaramakrishnan, Volvo Cars, sivaramakrishnan.swaminathan@volvocars.com	*1. Dr. K. Balasubramanian, Sri Krishna College of Engineering, balasubramanian@skcet.ac.in*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr.SarathRamakannan, Aston Martin, sharath.ramakrishnan@astonmartin.com	*2. Dr. S. Premnath, Sri Venkateswara College of Engineering, prem@svcce.ac.in*	*2. Dr. S. Thiyagarajan, SRMIST*

Course Code	18AUE341T	Course Name	AUTOMOTIVE DRIVELINE 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 :	*Design the driveline systems and its components*
CLR-2 :	*Distinguish the design of various flywheel and clutches*
CLR-3 :	*Analyze the stresses and design various gears*
CLR-4 :	*Compare and design different gearboxes*
CLR-5 :	*Design the different types of front and rear axles .*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify the different types power transmission drives*	*1,3*	*90*	*85*	*H*	*M*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-2 :	*Infer the design of various flywheel and clutches*	*1,2*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Classify and design different gears used in transmission systems*	*1,3*	*90*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-4 :	*Categorize and design different gearbox and shafts*	*1,3*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-5 :	*Interpret the design of various types of front and rear axles*	*1,4*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*

Duration (hour)		*Design of flexible drives*	*Design of flywheel and clutches*	*Design of Spur gear and Helical gear*	*Design of Gearbox, Propeller shaft*	*Design of final drive*
		9	9	9	9	9
S-1	SLO-1	*Flexible drives - Introduction*	*Flywheel and governor*	*Gears-Introduction*	*Gear box, components, requirements,*	*Axles-Types, materials*
	SLO-2	*Comparison of flexible drives with rigid drives*	*flywheel materials*	*Gear terminology and gear trains*	*Gear matching*	*Design requirements of front axle*
S-2	SLO-1	*Belt drives types and construction*	*Torque analysis*	*Design of spur gear, Selection of material*	*Requirements to obtain optimum design*	*Loads on axles*
	SLO-2	*Geometrical relationship*	*Stresses in Solid disc flywheel*	*Beam strength for gear tooth*	*Ray diagram, geometric progression and standard step ratio*	*Steering Knuckle*
S-3	SLO-1	*Analysis of belt tensions*	*Rimmed flywheel*	*Permissible bending stress*	*Kinematic layout*	*King pin*
	SLO-2	*Condition for maximum power*	*Stresses in rimmed flywheel*	*Effective load on gear tooth*	*Design of sliding mesh gear box*	*Rear Axle (drive Axle) tube*
S-4	SLO-1	*Pulley design for belt drives*	*Tutorial on flywheel design*	*Estimation of module based on beam strength*	*Design of gearbox*	*Design of front axle*
	SLO-2	*Tutorial on belt drives*	*Design considerations of clutches*	*Wear strength of Spur gear*	*Solving problems*	*Design of front axle*
S-5	SLO-1	*Introduction of chain drives*	*Torque Transmission Capacity, uniform pressure theory*	*Solving problems*	*Constant mesh gearbox*	*Solving problems*
	SLO-2	*Advantages of chain drives over belt drives*	*Uniform wear theory*	*Solving problems*	*Speed reducer unit*	*Solving problems*
S-6	SLO-1	*Roller chains*	*Design of single plate clutch*	*Terminology of helical gears*	*Design of propeller shaft for bending and torsion*	*Design of rear axle*
	SLO-2	*Geometrical relationship*	*Design of multidisc clutch*	*Force analysis of helical gears*	*Design of propeller shaft for bending and torsion*	*Design of rear axle*
S-7	SLO-1	*Polygonal effect*	*Friction materials*	*Force analysis of helical gears*	*Design of propeller shaft for rigidity*	*Solving problems*
	SLO-2	*Power rating for roller chains*	*Design of Cone clutches*	*Beam strength of helical gears*	*Solving problems*	*Solving problems*
S-8	SLO-1	*Design of sprocket wheels*	*Solving problems*	*Effective load on gear tooth*	*Design of universal joints*	*Design of fully floating axle*
	SLO-2	*Design of chain drive*	*Design of centrifugal clutches*	*Wear strength of helical gear*	*Design of CV joints*	*Design of half floating axle*

Duration (hour)		*Design of flexible drives*	*Design of flywheel and clutches*	*Design of Spur gear and Helical gear*	*Design of Gearbox, Propeller shaft*	*Design of final drive*
		9	9	9	9	9
S-9	SLO-1	*Chain lubrication*	*Energy equation for clutches*	*Estimation of module based on wear strength*	*Slip joint design*	*Design of dead axle*
	SLO-2	*Tutorial on chain drives*	*Thermal consideration in clutch design*	*Solving problems*	*Solving problems*	*Design of Final drive and differential*

Learning Resources	
1. *Bhandari. V. B., "Design of Machine Elements", Tata McGraw-Hill Publishing Company Ltd, 2010.* 2. *Gian Carlo Genta, Lorenzo lorello "The Automotive Chassis system design" published by Springer,2009*	3. *Joseph E. Shigley & Larry D. Mitchell, "Mechanical Engineering Design", 10 th Edition, McGraw-Hill International book company,2014* 4. *Julian Hapian Smith, "An Introduction to Modern Vehicle Design", Society of Automotive Engineers Inc,2002*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.T.R.Karthikeyan, TAFE, vasucar@gmail.com	*1. Dr..A.Samuel Raja, Thiyagarajar college of Engineering Madurai, samuel1973@tce.edu*	*1. Dr.R.Rajendran, SRMIST, rajendrr@srmist.edu.in*
2. Mr.R.Srikanth, Altair, srikanth.r@altair.com	*2. Mr. N.Ravikumar, Crescent Institute of Science and Technology, ravikumar@crescent.education*	*2. Mr.K.Devanathan, SRMIST, devanatk@srmist.edu.in*

Course Code	18AUE342T	Course Name	AUTOMOTIVE CHASSIS COMPONENT 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 :	*Design the chassis and its components.*
CLR-2 :	*Design the steering system and its components.*
CLR-3 :	*Design the braking system and its components.*
CLR-4 :	*Distinguish various suspension systems and designing it.*
CLR-5 :	*Gain knowledge about tire and its performance characteristics.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify different types of frames and loads acting on it.*	*1,3*	*90*	*85*	*H*	*M*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Interpret different steering system components.*	*1,2*	*90*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*M*
CLO-3 :	*Evaluate the braking systemcomponents and their design procedures.*	*1,3*	*90*	*75*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*M*	*M*
CLO-4 :	*Classify and design different suspension system and its components.*	*1,3*	*80*	*75*	*H*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*M*	*M*	*L*	*L*	*M*	*H*	*H*
CLO-5 :	*Infer about tires and their performance characteristics.*	*1,4*	*85*	*80*	*H*	*H*	*M*	*H*	*N*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*M*	*H*	*H*

Duration (hour)		*Frames*	*Steering*	*Brakes*	*Suspensions*	*Wheels and Tires*
		9	*9*	*9*	*9*	*9*
S-1	SLO-1	*Study of loads*	*Introduction Steering mechanism*	*The fundamentals of braking*	*Introduction*	*Description Rim characteristics*
	SLO-2	*Bending case*	*Steering mechanism and applications*	*Brake system components and configurations*	*Design of leaf Springs*	*Tire characteristics Wheel reference system*
S-2	SLO-1	*Torsion case*	*Rack and pinion steering box*	*Weight transfer during braking & effect of vehicle parameters*	*Design of Helical Springs*	*Tire operation On-road driving*
	SLO-2	*Combined bending and torsion*	*Screw and sector steering box*	*Disc brakes / Disc brake – types, advantages & disadvantages*	*Helical Springs in Series and Parallel and design of torsion bar*	*Off-road driving*
S-3	SLO-1	*Lateral loading*	*Design Steering column*	*Mechanical brake systems - components and configurations*	*Independent suspensions McPherson suspension*	*Rolling radius*
	SLO-2	*Fore and aft loading*	*Design Steering column*	*Hydraulic brake systems - components and configurations*	*McPherson suspensions for rear axle*	*Rolling radius*
S-4	SLO-1	*Frame materials*	*Steering column calculations*	*Air brake systems - components and configurations*	*Double wishbone suspension*	*Rolling resistance Effect of speed, material nature and structure, tread wear*
	SLO-2	*Design of frames*	*Recirculation ball steering diagnosis and service*	*Parking brake systems*	*Virtual centres suspensions*	*Effect of operating temperature, inflation pressure and vertical load, tire size, road wheel sideslip angle*
S-5	SLO-1	*Moment of inertia of rectangular section.*	*Principles of conventional column*	*Brake Friction materials – Brake pads & Brake Liner Composition and friction*	*Trailing arm suspensions- Semi-trailing arms suspension*	*Static Forces*
	SLO-2	*Moment of Inertia of a Hollow Rectangular Section.*	*Tilt column systems*	*Thermal effects in friction brakes*	*Multilink suspensions*	*Static Forces*
S-6	SLO-1	*Moment of Inertia of a Hollow Rectangular Section.*	*Collapsible steering column*	*Wheel lock and vehicle stability during braking*	*Semi-independent suspensions*	*Longitudinal Force*

	SLO-2	*Moment of Inertia of a Circular Section*	*Conventional steering linkage mechanism*	*Electronic braking system*	*Twist beam suspension*	*Longitudinal Force*
S-7	SLO-1	*Chassis types, introduction -Ladder frames -Cruciform frames*	*Rack and pinion steering linkage mechanism*	*Brake system legislation*	*Rigid axle suspensions - Rigid axles with leaf springs*	*Cornering forces*
	SLO-2	*Torque tube backbone frames- Space frames-*	*Manual And Power Steering Theory*	*Brake testing*	*Rigid guided axles*	*Interaction between longitudinal and side forces*
S-8	SLO-1	*Integral structures*	*Manual steering*	*Brake NVH*	*Industrial vehicles suspensions - Pneumatic springs*	*Outline on dynamic behavior*
	SLO-2	*Underbody, Sub-frame, Industrial vehicle frames*	*Power steering*	*Stopping distance calculation*	*Front suspension Rear suspensions*	*Outline on dynamic behavior*
S-9	SLO-1	*Structural tasks Structural design*	*Power steering pump operation*	*Brake factor calculation for a drum brake / Disc brake*	*Design and testing*	*Testing of tires*
	SLO-2	*Structural testing*	*Rack and pinion steering diagnosis and service*	*Brake torque calculation in a hydraulic system*	*Design and testing*	*Testing of tires*

Learning Resources	1. *The Automotive Chassis Volume 1: Components Design Genta, Giancarlo, Morello, L., Springer, Netherlands 2009.* 2. *Introduction to Modern Vehicle Design Julian Happian-Smith, Butterworth-Heinemann 2001.* 3. *Vector Mechanics for Engineers: Statics and Dynamics Beer, Johnston, McGraw Hill Education; Tenth edition 2017*	4. *Advanced Vehicle Technology Heinz Heisler, Butterworth-Heinemann; 2 edition 2002.* 5. *The Motor Vehicle Kenneth Newton , T.K. Garrett , W. Steeds, Butterworth-Heinemann 12 Revised edition 1997*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.N. Vijayakumar Mahindra & Mahindra, vijayakumar.n@mahindra.com	*1. Mr. B.Vasanthan, Madras Institute of technology, Anna University, bvasanthan@mitindia.edu*	*1.Dr. R. Rajendran, SRMIST, rajendrr@srmist.edu.in*
2. Mr..R.Srikanth, Altair, srikanth.r@altair.com	*2. Mr.N.Ravikumar,Crescent Institute of Science and Technology,ravikumar@crescent.education*	*2. Mr. T. Kaviyarasu ,SRMIST, kaviyart@srmist.edu.in*

Course Code	18AUE344T	Course Name	CONCEPTS OF ENGINEERING 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 :	*Familiarize the students with the design process*
CLR-2 :	*Give insights into the various tools used in Design Methods*
CLR-3 :	*Acquaint students with material selection and design strategies*
CLR-4 :	*Familiarize the students with the Engineering statistics and reliability in design*
CLR-5 :	*Give insights into legal and ethical issues in Designing and to various tools involved in Quality Engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Describe various design processes*	*1*	*85*	*80*	*H*	*-*	*H*	*L*	*L*	*L*	*L*	*-*	*M*	*M*	*L*	*M*	*M*	*M*	*L*
CLO-2 :	*Demonstrate various tools used in Design Methods*	*2*	*80*	*75*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*-*	*M*	*M*	*-*	*M*	*M*	*M*	*H*
CLO-3 :	*Understand the process of material selection and can interpret various techniques involved in Design*	*1,2*	*85*	*80*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-4 :	*Implement various Engineering statistics methods in design*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*-*	*M*	*M*	*M*	*M*
CLO-5 :	*Understand the legal and ethical issues in Designing and apply various tools used in Quality Engineering*	*1.2*	*85*	*80*	*H*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*M*	*H*

Duration (hour)		Design Process	Design Methods	Material Selection Processing and Design	Engineering Statistics and Reliability	Legal and Ethical Issues in Design and Quality Engineering
		9	9	9	9	9
S-1	SLO-1	*The Design Process*	*Creativity and Problem Solving, Product Design Specifications*	*Material Selection Process*	*Introduction to statistics and Reliability*	*Introduction to Ethics*
	SLO-2	*Morphology of Design, Design Drawings*	*Conceptual Design*	*Economics, Cost vs Performance*		*The Origin Of Laws*
S-2	SLO-1	*Computer Aided Engineering, Designing of Standards*	*Decision Theory, Decision Tree*	*Weighted Property Index*	*Probability*	*Contracts*
	SLO-2	*Concurrent Engineering*	*Embodiment Design*	*Value Analysis, Role of Processing in Design*		*Liability*
S-3	SLO-1	*Product Life Cycle*	*Detail Design, Mathematical Modeling*	*Classification of Manufacturing Process*	*Distributions*	*Tort Law*
	SLO-2	*Technological Forecasting*				*Product Liability*
S-4	SLO-1	*Market Identification*	*Simulation, Geometric Modeling*	*Design for Manufacture*	*Test Of Hypothesis*	*Protecting Intellectual Property*
	SLO-2					
S-5	SLO-1	*Competition Bench Marking*	*Finite Element Modeling*	*Design for Assembly*	*Design Of Experiments*	*Legal and Ethical Domains*
	SLO-2					*Codes of Ethics*
S-6	SLO-1	*Systems Engineering*	*Optimization, Search Methods*	*Designing for Castings, Forging*	*Reliability Theory*	*Solving Ethical Conflicts*
	SLO-2					
S-7	SLO-1	*Life Cycle Engineering*	*Geometric Programming*	*Designing for Metal Forming, Machining and Welding*	*Design for Reliability*	*Total Quality Concept, – Quality Assurance*
	SLO-2					*Statistics Process Control*
S-8	SLO-1	*Human Factors in Design*	*Structural Optimization*	*Residual Stresses*	*Reliability Centered Maintenance*	*Taguchi Methods*
	SLO-2					*Robust Design*

Duration (hour)		Design Process	Design Methods	Material Selection Processing and Design	Engineering Statistics and Reliability	Legal and Ethical Issues in Design and Quality Engineering
		9	9	9	9	9
S-9	SLO-1	*Industrial Design*	*Shape Optimization*	*Fatigue, Fracture and Failure*	*Tutorial*	*Failure Mode Effect Analysis*
	SLO-2					

Learning Resources		
	1. *Dieter, George E., Engineering Design - "A Materials and Processing Approach", McGraw Hill International Editions, Singapore, 4th Edition, 2008* 2. *Karl T. Ulrich and Steven D. Eppinger "Product Design and Development" McGraw Hill Edition 6th edition 2015*	3. *Pahl, G, and Beitz, W.," Engineering Design: A Systematic Approach", Springer London, 2014* 4. *Ray, M.S., "Elements of Engg. Design", Prentice Hall Inc. 1985.* 5. *Suh, N.P., "The principles of Design", Oxford University Press, NY.1990.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.R Siva GMMCO, rsiva@gmmco.com	*1.Dr. K.Chandrasekaran, RMK Engg. College, dean.mech@rmkec.ac.in*	*1. Dr. K. Kamalakkannan, SRMIST , kamalakk1@srmist.edu.in*
2.Mr.Prasad MP AGNITO INSIGHTS, prasad@agnito.in	*2. Dr. V. Uma Maheshwar ,Osmania University mahesh.v@uceou.edu,*	*2. Mr. R. Ganesh, SRMIST, ganeshr@srmist.edu.in*

Course Code	18AUE345T	Course Name	RAPID PROTOTYPING AND TOOLING	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 and use techniques for processing of CAD models for rapid prototyping.*
CLR-2 :	*Understand and apply fundamentals of rapid prototyping techniques.*
CLR-3 :	*Use appropriate tooling for rapid prototyping process.*
CLR-4 :	*Use rapid prototyping techniques for reverse engineering.*
CLR-5 :	*Examine the cases relevant to mass customization and some of the important research challenges associated with AM and its data processing tools*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand history, concepts and terminology of additive manufacturing*	*2*	*95*	*93*	*H*	*L*	*L*	*H*	*L*	*L*	*M*	*L*	*H*	*L*	*H*	*H*	*H*	*M*	*H*
CLO-2 :	*Apply the reverse engineering concepts for design development*	*2*	*98*	*96*	*H*	*L*	*L*	*H*	*L*	*L*	*M*	*L*	*H*	*L*	*H*	*H*	*H*	*M*	*H*
CLO-3 :	*Understand the variety of additive manufacturing techniques*	*2*	*96*	*95*	*H*	*L*	*L*	*H*	*L*	*L*	*M*	*L*	*H*	*L*	*H*	*H*	*H*	*M*	*H*
CLO-4 :	*Design and develop newer tooling models*	*2*	*98*	*97*	*H*	*L*	*L*	*H*	*L*	*L*	*M*	*L*	*H*	*L*	*H*	*H*	*H*	*M*	*H*
CLO-5 :	*Analyse the cases relevant to mass customization and some of the important research challenges associated with AM and its data processing tools*	*2*	*94*	*91*	*H*	*L*	*L*	*H*	*L*	*L*	*M*	*L*	*H*	*L*	*H*	*H*	*H*	*M*	*H*

Duration (hour)		Introduction to Rapid Prototyping	Liquid Based Additive Manufacturing System	Solid Based Additive Manufacturing System	Powder Based Additive Manufacturing System	Additive Manufacturing Application And Case Studies
		9	9	9	9	9
S-1	SLO-1	*Overview of subtraction and additive*	*Methods in liquid based process and*	*Introduction to solid based additive*	*Methods in powder based process*	*Design for additive manufacturing method*
	SLO-2	*manufacturing History*	*material used for fabrication*	*Manufacturing system*		*and*
S-2	SLO-1	*Need-Classification of additive manufacturing*	*Stereo lithography Apparatus (SLA)-*	*Methods in solid based process and*	*and material used for fabrication*	*special materials*
	SLO-2	*Need-Classification of additive manufacturing*	*Principle, process,*	*material used for fabrication*	*Selective Laser Sintering*	*medical and bio-additive manufacturing*
S-3	SLO-1	*The cost and effects of design changes during conceptual modeling, detail*	*advantages, disadvantages and limitations*	*fused deposition modeling(FDM)- introduction*	*Principles of SLS–process*	*Customized implants and prosthesis: Design*
	SLO-2	*designing, prototyping,*	*Digital light processing -introduction*	*fused deposition modeling(FDM)- principle*	*Process, advantages and*	*and production*
S-4	SLO-1	*manufacturing and product release*	*Digital light processing principle*	*Process*	*Applications*	*Bio-Additive Manufacturing-*
	SLO-2	*Reverse Engineering*	*Process*	*Advantages and dis advantages*	*Selective Laser Melting*	*Computer Aided Tissue Engineering (CATE)*
S-5	SLO-1	*Bench marking*	*Advantages and dis advantages*	*Limitation Limitations*	*Principles of SLS process*	*Advantages and dis advantages*
	SLO-2	*3D scanning, 3D digitizing and Data fitting*	*Limitations*	*Multi jet modelling- Principle*	*Process, advantages and applications*	*Application of RP techniques in Automotive components-*
S-6	SLO-1	*CAD for RPT: CAD model preparation*	*Solid ground curing introduction*	*process, advantages,*	*Selective heat sintering*	*3D printed brake caliper*
	SLO-2	*Part Orientation and support generation*	*Solid ground curing principle*	*disadvantages and limitations*	*Laser Engineered Net Shaping (LENS) -,*	*3D printed food- need and*
S-7	SLO-1	*Model Slicing –Tool path Generation*	*Process*	*Laminated object modeling (LOM)- Principle, process,*	*Principle, process, advantages*	*its limitation*

Duration (hour)		Introduction to Rapid Prototyping	Liquid Based Additive Manufacturing System	Solid Based Additive Manufacturing System	Powder Based Additive Manufacturing System	Additive Manufacturing Application And Case Studies
		9	9	9	9	9
	SLO-2	*Materials for Additive Manufacturing Technology*	*Advantages and dis advantages*	*advantages, disadvantages and limitations*	*disadvantages and limitations*	*zero-gravity 3D printer*
S-8	SLO-1	*And its classification based on materials*	*Limitations*		*Three Dimensional Printing - Principle, process,*	*Application of RP in Art and jewelry*
	SLO-2	*RPT and its role in modern manufacturing mechanical design*	*Continuous Liquid Interface Production*	*Electron-beam freeform fabrication*	*advantages and applications-*	*Challenges in implementation of RP techniques*
S-9	SLO-1	*-Economics of RP techniques*	*Shape deposition modelling*	*Case studies*	*Electron Beam Melting- Principle, process,*	*Case Studies*
	SLO-2		*Ballistic Particle Manufacturing(BPM)*		*advantages, disadvantages and limitations*	

Learning Resources	
1. *Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.*	3. *Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.*
2. *Gebhardt, A., "Rapid prototyping", Hanser Gardener Publications, 2003.*	4. *Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.K Suresh, HAL, Sureshhal82@gmail.com	*1.Dr.P D Jeyakumar, Cresent University, pdjeyakumar@cresent.education*	*1.. Dr K. Kamalakkannan SRMIST kamalakk1@srmist.edu.in*
2.Mr.Ajeesh Varghese Halla, Ajeeshvarghese@halla.com	*2.Dr.K Prabu VIT, Prabu.k@vit.ac.in*	*2.Mr.S.Devanand,SRMIST, devanans@srmist.edu.in*

Course Code	18AUE346T	Course Name	MODELING AND CONTROL OF VIBRATION IN MECHANICAL 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 :	*Impart knowledge on fundamentals of vibrations*
CLR-2 :	*Know the concept of two degree of freedom systems and continuous systems*
CLR-3 :	*Analyze different methods of modeling multi degree of freedom systems*
CLR-4 :	*Understand the concept of Vibration control techniques*
CLR-5 :	*Gain knowledge on vibration measurement devices*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the fundamentals of vibration and single degree of freedom system*	*1,3*	*90*	*85*	*H*	*M*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-2 :	*Implement two degree of freedom systems in any application*	*1,2*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Classify the different modeling methods in multi degree of freedom systems*	*1,3*	*90*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-4 :	*Interpret different vibration control techniques*	*1,3*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-5 :	*Implement the vibration measurement devices in real time application*	*1,4*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*

Duration (hour)		Fundamentals of vibration and Modelling SDOF systems	Two degree of freedom systems and continuous systems	Modelling of Multi-DegreeofFreedom Systems	Vibration control	Vibration measurement and applications
		9	9	9	9	9
S-1	SLO-1	*Concept of vibration*	*Two DOF*	*Multi Degree Freedom System*	*Introduction to vibration control*	*Transducers*
	SLO-2					
S-2	SLO-1	*Classification of vibration*	*Modelling of Two Degree of freedom systems*	*Modeling of Continuous Systems as Multi-degreeofFreedom Systems*	*Specification of Vibration Limits*	*Transducers types and applications*
	SLO-2	*Vibration analysis procedure and elements*	*Modelling of Two Degree of freedom systems*	*Influence Coefficients*	*Static and dynamic balancing*	*Vibration pickups*
S-3	SLO-1	*Harmonic and periodic motions, vibration terminology*	*Free Vibration Analysis of an Undamped System*	*stiffness coefficients*	*Balancing of Rotating Machines*	*Vibrometer*
	SLO-2	*Modelling of single degree of freedom systems*	*Free Vibration Analysis of dampedSystem*	*Flexibility and inertia influence coefficients*	*Field balancing*	*Accelerometer*
S-4	SLO-1	*Vibration model, Equation of motion-Natural Frequency*	*Equations of Motion for ForcedVibration*	*Flexibility Matrixand Stiffness Matrix*	*Whirling of Rotating Shafts*	*Velometer*
	SLO-2	*Energy method, Rayleigh method*	*Forced Vibration with HarmonicExcitation System*	*Flexibility Matrixand Stiffness Matrix*	*Critical Speeds, Stability Analysis*	*Phase Distortion*
S-5	SLO-1	*Principle of virtual work,*	*Forced Vibration with HarmonicExcitation System*	*Eigen Values and Eigen Vectors*	*Balancing of Reciprocating Engines*	*Frequency-Measuring Instruments*
	SLO-2	*Damping models.*	*Coordinate Couplings and Principal Coordinates*	*Eigen Values and Eigen Vectors*	*Control of Natural Frequencies*	*Vibration Exciters*
S-6	SLO-1	*Viscously damped free vibration*	*Vibration of continuous systems*	*Matrix Iteration Method*	*Vibration Isolation*	*Signal Analysis*
	SLO-2	*Special cases: oscillatory, non-oscillatory and critically damped motions.*	*Vibrating string*	*ApproximateMethods*	*Vibration Isolation methods*	*Dynamic Testing of Machines and Structures*

Duration (hour)		Fundamentals of vibration and Modelling SDOF systems	Two degree of freedom systems and continuous systems	Modelling of Multi-DegreeofFreedom Systems	Vibration control	Vibration measurement and applications
		9	9	9	9	9
S-7	SLO-1	*Logarithmic decrement, Experimental determination of damping coefficient.*	*Longitudinal vibration of rods*	*Dunkerley, Rayleigh's, and Holzer Method*	*Vibration Absorbers*	*Experimental Modal Analysis*
	SLO-2	*Forced harmonic vibration, Magnification factor.*	*Torsional vibration of rods*	*Geared Systems*	*Dynamic vibration absorbers*	*Measurement of Mode Shapes*
S-8	SLO-1	*Rotor unbalance, Transmissibility*	*Vibration of suspension bridges*	*Eigen Values & Eigenvectors for large system of equations using sub space*	*torsional and pendulum type absorbers*	*Machine Condition Monitoring and Diagnosis*
	SLO-2	*Vibration Isolation*	*Euler equation for beams*	*Solving problems*	*Damped vibration absorbers*	*Machine Condition Monitoring and Diagnosis*
S-9	SLO-1	*Equivalent viscous damping, Sharpness of resonance.*	*Cycle test 2*	*Cycle test 2*	*Cycle test 3*	*Cycle test 3*
	SLO-2	*Cycle test 1*	*cycle test 2*	*cycle test 2*	*Cycle test 3*	*Cycle test 3*

Learning Resources	
1. *Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa, New Delhi, 2010* 2. *Rao, S.S.," Mechanical Vibrations," Addison Wesley Longman, 6th Edition 2018.*	3. *S. Graham Kelly &Shashidar K. Kudari, "Mechanical Vibrations", Tata McGraw–Hill Publishing Com. Ltd New Delhi, 2007* 4. *4. Thomson, W.T. – "Theory of Vibration with Applications", CBS Publishers and Distributors, New Delhi, 2006*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. Dhanraj domala, Design Engineer, Xitadel Dhanraj.domala@xitadel.com	*1.Dr.M.Subramanian , Associate Professor, PSG Tech, msn.auto@psgtech.ac.in*	1. *Dr K. Kamalakkannan SRMIST Kamalakk1@srmist.edu.in*
2. Mr.GopalDhanasekar, System Engineer, Automotive Testing System. Gopal.dhanasekar@ats_india.com	*2. Dr. R Kannan, Professor, PSNA CET Kannanjothy@gmail.com*	2. *Dr. T.Praveenkumrar, SRMIST praveent@srmist.edu.in*

Course Code	18AUE347T	Course Name	GEOMETRICAL DIMENSIONING AND TOLERANCE	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 :	Apply the standard dimensioning practices for mechanical drawings
CLR-2 :	Gain knowledge on tolerancing in part diagrams
CLR-3 :	Use the concept of geometric tolerancing in part diagrams
CLR-4 :	Interpret the Form and orientation control with GD&T
CLR-5 :	Interpret the Profile and location control with GD&T

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment &	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	Students gain knowledge and expertise in the field of electrical and electronics related to automotive systems	Ability to understand recent technological developments in Automotive electronics and develop products to cater the societal and industrial needs	Assess society needs and develop constructive and creative solutions for problems related to Automotive Electronics
CLO-1 :	Sketch a part diagram with proper dimensioning according to the standards	1	85	80	H	M	H	M	L	M	M	H	M	H	H	H	H	H	H
CLO-2 :	Connect the tolerance with dimensioning and its implementation	2	80	75	H	M	M	L	L	M	M	M	H	H	L	H	H	H	H
CLO-3 :	Drew a part diagram with GD&T symbols	3	85	80	H	H	H	H	H	M	H	M	M	M	H	H	H	H	H
CLO-4 :	Recognize its important and usage in manufacturing	2	80	75	H	H	H	H	M	M	M	M	M	M	M	H	H	H	H

Duration (hour)		Dimensioning Overview	Tolerances and its implementation	GD&T symbols and Datum	Form and orientation controls	Profile and location controls
		9	9	9	9	9
S-1	SLO-1	Basic Concepts	Tolerance Representation	Need for GD&T	Flatness	Profile of a line, surface
	SLO-2	Terminologies used in dimensioning	General Tolerances	Benefits of GD&T	Flatness – verification techniques	Inspecting profile of a line, surface
S-2	SLO-1	Location and Orientation Dimensions	Limit Dimensions	Technical standards	Straightness	Planer Coplanarity
	SLO-2	Location and Orientation Dimensions-cont.	Plus and Minus Dimensions	GD&T symbols	Surface and midplane control	Conicity
S-3	SLO-1	Symbols for Drilling Operations, Dimensioning a Blind Hole	Single Limit Dimensions	How to read a feature control frame	Circularity	Runout – circular runout and total runout
	SLO-2	Placement, Spacing, Extension Lines	Important Terms in tolerancing	Datums – introduction	Circularity verification techniques	Inspection of runouts
S-4	SLO-1	Grouping and Staggering	Allowances	Datum vs. datum feature	Circularity on cylinder and cone	Concentricity
	SLO-2	Reading Direction, View Dimensioning	Different between tolerance and allowances	The datum reference frame	Theory vs reality in measuring circularity	Position - Projected tolerance zone
S-5	SLO-1	Repetitive Features, Detail Dimensioning	Fit Types	3-2-1 locating principle	Evaluation of roundness	Positional co-axiality
	SLO-2	Dimensioning Concentric Circles	Clearance fit	Uncertainties in datum establishment	Cylindricity	Zero tolerancing
S-6	SLO-1	Detail Dimensioning	Interference fit	Common misconceptions in datum	Method of measuring deviation from cylindricity	Composite tolerancing
	SLO-2	Diameter versus Radius	Transition fit	Profile of a line, surface	Angularity and its measurement method	A logical approach to part tolerancing
S-7	SLO-1	Dimensioning Guidelines	Clearance and Interference Fits between Two Shafts and a Hole	Maximum material condition	Perpendicularity	A logical approach to part tolerancing – cont.
	SLO-2	Dimensioning Guidelines – cont.	Transition Fit between a Shaft and a Hole	Least material condition	Perpendicularity verification techniques	Refining functional geometric controls to be more cost effective
S-8	SLO-1	Principles of Good Dimensioning	Basic Hole System	Regardless of feature size	Shifting vs growing	Push pin gages – advantages
	SLO-2	Importance of dimensioning	Basic Shaft System	The Tylor principle	Parallelism and its measuring techniques	Push pin gages – tolerance distribution

Duration (hour)		*Dimensioning Overview*	*Tolerances and its implementation*	*GD&T symbols and Datum*	*Form and orientation controls*	*Profile and location controls*
		9	9	9	9	9
S-9	SLO-1	*Example with 2D drawings*	*Example with Thread Notes*	*Virtual boundaries*	*Free state inspection of flexible parts*	*Tolerance on the work*
	SLO-2	*Example with 2D drawings – cont.*	*Example with Thread Notes- cont.*	*Problem on finding wall thickness*	*Restrained state control of flexible parts*	*Tolerance on the work- cont.*

Learning Resources	*1. Alex Krulikowski, Fundamentals of Geometric Dimensioning and Tolerancing,Delmar Cengage Learning 2E, 1997* *2. James D. Meadows, Geometric Dimensioning and Tolerancing: Applications and Techniques for Use in Design: Manufacturing, and Inspection,CRC Press,1995*	*3. Gary R.Bertoline , Introduction to graphics communications for engineers, McGraw-Hill, 4th edition*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	*30%*	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	*40%*	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Dalpat Singh, M & M,singh.dalpat@mahindra.com	*1. Mr.J.MahasharAli,Crescent Institute of Science and Technology, mahashar@crescent.education*	*1. Dr..K.Kamalakkannan, SRMIST*
2. Mr. Nirmal Kumar, Hubell India, nirmal06kumar@gmail.coml	*2. Dr.K.Kalaichelvan, Anna University, kalaichelvan@annauniv.edul*	*2. Dr.R.Rajendran, SRMIST*

Course Code	15AUE348T	Course Name	DESIGN FOR MANUFACTURE	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			

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Illustrate design of manufacturing process for casting and forming
CLR-2 :	Illustrate design of manufacturing process for extrusion
CLR-3 :	Illustrate design of manufacturing process for machining
CLR-4 :	Illustrate design of manufacturing process for joining
CLR-5 :	Devise assembly process of manufactured components

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Describe various manufacturing process and design processes for casting and forming process	1	80	75	H	M	M	M	H	M	M	H	M	M	H	H	H	H	H
CLO-2 :	Describe various manufacturing process and design processes for Extrusion process	2	85	80	H	H	H	M	L	M	M	M	M	M	H	H	H	H	H
CLO-3 :	Describe various manufacturing process and design processes for machining process	3	85	80	H	H	H	H	L	M	M	M	M	M	H	H	H	H	H
CLO-4 :	Describe various manufacturing process and design processes for Joining process	3	80	75	H	H	H	H	L	M	M	M	M	M	H	H	H	H	H
CLO-5 :	Design various assembly process of automotive components	3	85	80	H	H	H	H	L	M	M	M	H	M	H	H	H	H	H

Duration (hour)		Design for Manufacture and Casting	Design for Forming and Extrusion	Design for Machining	Design for Welding and Joining	Design for Assembly
		9	9	9	9	9
S-1	SLO-1	*Introduction to Design for Manufacture and Casting*	*Introduction to Design for Extrusion*	*Introduction to Design for Machining*	*Introduction to Design for Joining process*	*Introduction to Design for Assembly*
	SLO-2	*Economics of process selection*	*Introduction to Design for forming and forging*	*Introduction to Design for Machining*	*Design Recommendation for Solder and Brazzed Assembly*	*Introduction to Design for Assembly*
S-2	SLO-1	*Introduction to materials and material selection*	*Various extrusion process*	*Design considerations for turned operation*	*Design Recommendation for Adhesively Bonded Assemblies*	*General assembly recommendations*
	SLO-2	*Mechanical properties of materials*	*Comparison of Various extrusion process*	*Design considerations for turned operation*	*Design Recommendation for Welding*	*General assembly recommendations*
S-3	SLO-1	*General design principles for manufacturability*	*Design considerations for Hot extruded parts*	*Design for machining round holes*	*Design Recommendation for Welding*	*Minimizing the number of parts in Assembly*
	SLO-2	*General design principles for manufacturability*	*Design considerations for Hot extruded parts*	*Design for machining round holes*	*Cost reduction and Minimizing distortion*	*Minimizing the number of parts in Assembly*
S-4	SLO-1	*Design considerations for Sand cast*	*Design considerations for Impact/Cold extruded parts*	*Parts produced by milling*	*Design considerations for Weld strength*	*Design considerations for Rivets*
	SLO-2	*Design considerations for Sand cast*	*Design considerations for Impact/Cold extruded parts*	*Design considerations for milling*	*Design considerations for Weldment & heat treatment*	*Design considerations for Rivets*
S-5	SLO-1	*Design considerations for Die cast*	*Design considerations for Stamped parts*	*Parts produced by planning*	*Parts joined by resistance welding*	*Design considerations for Screw fasteners*
	SLO-2	*Design considerations for Die cast*	*Design considerations for Stamped parts*	*Design considerations for planning*	*Design considerations for resistance welding*	*Design considerations for Screw fasteners*
S-6	SLO-1	*Design considerations for Permanent mould cast parts*	*Design considerations for Forged parts*	*Parts produced by shaping*	*Parts joined by spot welding*	*Design considerations for Gasket & Seals*
	SLO-2	*Design considerations for Permanent mould cast parts*	*Design considerations for Forged parts*	*Design considerations for shaping*	*Design considerations for spot welding*	*Design considerations for Gasket & Seals*

Duration (hour)		Design for Manufacture and Casting	Design for Forming and Extrusion	Design for Machining	Design for Welding and Joining	Design for Assembly
		9	9	9	9	9
S-7	SLO-1	*Design considerations for Centrifugal cast parts*	*Design considerations for Forming*	*Parts produced by slotting*	*Parts joined by seam welding*	*Design considerations for Press fits*
	SLO-2	*Design considerations for Centrifugal cast parts*	*Design considerations for Forming*	*Design considerations for slotting*	*Design considerations for seam welding*	*Design considerations for Snap fits*
S-8	SLO-1	*Design considerations for Investment cast parts*	*Design considerations for Fine blanked parts*	*Design considerations for Polishing*	*Parts joined by Projection welding*	*Design considerations for Automatic assembly*
	SLO-2	*Design considerations for Investment cast parts*	*Design considerations for Fine blanked parts*	*Design considerations for Plating*	*Design considerations for Projection welding*	*Design considerations for Automatic assembly*
S-9	SLO-1	*Design for powder metal casting*	*Design considerations for Metal injection molded parts*	*CLA-2*	*Parts joined by Flash & Upset weldment*	*CLA-3*
	SLO-2	*CLA-1*	*Design considerations for Metal injection molded parts*	*CLA-2*	*Design considerations for Flash & Upset weldment*	*CLA-3*

Learning Resources	
1. *Corradopoli, "Design for Manufacture – A structured approach", CRC Press, 2001.* 2. *O. Molloy, E.A. Warman, S. Tilley, Design for Manufacturing and Assembly: Concepts, Architectures and Implementation, Springer, 1998.*	3. *Erik Tempelman, Hugh Shercliff, Bruno Ninaber van Eyben, Manufacturing and Design: Understanding the Principles of How Things Are Made, Elsevier, 2014.* 4. *Henry Peck, "Designing for Manufacture", Sir Isaac Pitman & Sons Ltd., 1973.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.N.Vijayakumar, Head Test labs, Mahindra and Mahindra, VIJAYAKUMAR.N@mahindra.com.	*1. Prof. M.Balasubramanian, Professor, IIT Madras, mbala@iitm.ac.in*	*1.Mr.G. NARESH, SRMIST, nareshg@srmist.edu.in*
2.Mr.Prasad Arun Kumar, Mahindra Research Valley, prasad.arunkumar@mahindra.com	*2. Dr.P.Jawahar, Assistant Professor, NIT Agartala, drjawahar.me@nita.ac.in*	*2. Dr. KAMALAKKANNAN, SRMIST, kamalakk1@srmist.edu.in*

Course Code	18AUE441T	Course Name	OPTIMIZATION TECHNIQUES IN ENGINEERING DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18MAB202T*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Automobile Engineering*	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize Unconstrained Optimization Techniques*
CLR-2 :	*Familiarize Constrained Optimization Techniques*
CLR-3 :	*Illustrate the Bio-inspired Optimization Techniques*
CLR-4 :	*Give insights into Fuzzy logic and Neural networks*
CLR-5 :	*Acquaint students with optimization in Static and Dynamic Applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Correlate single and multivariable optimization*	*1*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-2 :	*Apply the direct and indirect methods for constrained optimization problem*	*2*	*85*	*80*	*H*	*H*	*H*	*M*	*L*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Solve Multi objective optimization problems*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Develop the Fuzzy logic and Neural networks*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Apply optimization techniques in Static and Dynamic Applications*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		Unconstrained Optimization Techniques	Constrained Optimization Techniques I	Advanced Optimization Techniques	Fuzzy logic and Neural networks	Static and Dynamic Applications
		9	9	9	9	9
S-1	SLO-1	*Unconstrained Optimization*	*Constrained Optimization*	*Advanced Optimization*	*Fuzzy logic and Neural networks*	*Static and Dynamic Applications*
	SLO-2					
S-2	SLO-1	*Classification of optimization problems*	*Optimization with equality constraints*	*Multi stage optimization – dynamic programming*	*Fuzzy Set Theory*	*Structural Design applications*
	SLO-2					
S-3	SLO-1	*General principles of optimization*	*Optimization with inequality constraints*	*Multi stage optimization –stochastic programming*	*Optimization of Fuzzy Systems*	*Design and optimization of shafts*
	SLO-2					
S-4	SLO-1	*Problem formulation*	*Introduction to Direct methods*	*Multi objective optimization*	*Computational Procedure and Numerical Results*	*Design and optimization of springs*
	SLO-2					
S-5	SLO-1	*Single variable optimization*	*Introduction to Indirect methods*	*Genetic algorithms*	*Demonstration of Fuzzy logic using Matlab*	*Introduction to Dynamic Applications*
	SLO-2					
S-6	SLO-1	*Multivariable optimization*	*Indirect methods using penalty functions*	*Simulated Annealing algorithm*	*Introduction to Neural networks*	*Optimum design of single, two degree of freedom systems*
	SLO-2					
S-7	SLO-1	*Techniques of unconstrained minimization*	*Indirect methods using Lagrange multipliers*	*Problems on Genetic algorithms and Simulated Annealing algorithm*	*Neural-Network-Based Optimization*	*Optimum design of vibration absorbers*
	SLO-2					
S-8	SLO-1	*Search methods*	*Geometric programming*	*Ant colony Optimization*	*Feedforward networks for Classification and Regression*	*Application of optimization in Mechanisms*
	SLO-2					
S-9	SLO-1	*Interpolation methods*	*Problems on Geometric programming*	*Particle Swarm Optimization*	*Demonstration of Neural network using Matlab*	*Optimum design of simple linkage mechanisms*
	SLO-2					

Learning Resources	
	1. *S. SingaresuRao, "Engineering Optimization – Theory & Practice", New Age International (P) Limited, New Delhi, 2016.*
	2. *D.K. PratiharNarosa , "Soft Computing: Fundamentals and Applications", Publishing House, New-Delhi, 2014*
	3. *Kalyanamoy Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall of India Pvt. 2012.*
	4. *Goldberg, D.E., "Genetic algorithms in search, optimization and machine", Barnen, Addison- Wesley, New York, 2008.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.R.Rajasekar, RAMBAL Raj@rambalindia.net	*1.Dr.M.Rajesh, Arba minch institute of technologyRajesh.m@amu.edu.et*	*1. Dr. K.Kamalakkannan SRMIST kamalakk1@srmist.edu.in*
2.Mr.V.Raja Raman Altair rajarav@asiapac.altair.com	*2.Dr.P D Jeyakumar, Cresent University pdjeyakumar@cresent.education*	*2. Mr.G.Naresh ,SRMIST , nareshg@srmist.edu.in*

Course Code	18AUE442T	Course Name	MULTIBODY DYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18MAB202T*	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:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	*Understand the basics of multibody systems*																		
CLR-2 :	*Analyze kinematic parameters of multibody systems using computational approach*																		
CLR-3 :	*Solve for dynamics of multibody systems using computational approach*																		
CLR-4 :	*Model simple mechanisms and write its constraint equations*																		
CLR-5 :	*Simulate planar and spatial mechanisms using standard MBD package*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*formulate a model and free body diagram of multibody systems*	*1*	*80*	*70*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*L*	*M*	*L*	*H*	*H*	*M*	*M*
CLO-2 :	*derive the equations of motion of a multibody system*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*L*	*M*	*L*	*H*	*H*	*M*	*M*
CLO-3 :	*incorporate constraints into a multibody system*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*L*	*M*	*L*	*H*	*H*	*M*	*M*
CLO-4 :	*simulate the motion of a multibody system with a computer*	*3*	*90*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*M*	*L*	*M*	*L*	*H*	*H*	*M*	*M*
CLO-5 :	*interpret and analyze the results of simulation*	*3*	*90*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*M*	*L*	*M*	*L*	*H*	*H*	*M*	*M*

Duration (hour)		Multibody Systems Introduction	Kinematic and Dynamic Analysis	Kinematics of Mechanical Systems	Constrained Kinematics	Applications to Simple Mechanisms
		9	9	9	9	9
S-1	SLO-1	*Classical approach*	*Position analysis*	*Mechanical joints*	*Kinematics of a point moving on a rigid body*	*Computer formulation of joint constraints*
	SLO-2					
S-2	SLO-1	*Emergence of computational dynamics*	*Velocity analysis*	*Constraint equation for planar joints*	*Constrained kinematics*	*Computer algorithm*
	SLO-2	*Rigid / flexible multibody systems*	*Acceleration analysis*	*Constraint equation for planar joints*	*Constrained kinematics*	*Computer algorithm*
S-3	SLO-1	*Degrees of freedom*	*Two DOF robot manipulator –kinematic analysis*	*Constraint equation for spatial joints*	*Absolute co-ordinates*	*Flowchart for kinematic analysis*
	SLO-2	*Constrained / unconstrained motion*	*Two DOF robot manipulator –kinematic analysis*	*Constraint equation for spatial joints*	*Driving co-ordinates*	*Flowchart for kinematic analysis*
S-4	SLO-1	*Mechanical joints overview*	*Classical Versus computational approach*	*Mobility criteria*	*Formulation of joint constraints*	*Kinematic modeling and analysis*
	SLO-2	*Prismatic joint*	*General purpose computer program*	*Numerical –slider crank mechanism*	*Ground constraints*	*Kinematic modeling and analysis*
S-5	SLO-1	*Revolute joint*	*Force analysis overview*	*Co-ordinate transformation*	*Revolute and prismatic joint*	*Application to slider crank mechanism*
	SLO-2	*Cylindrical joint*	*Inertia forces*	*Co-ordinate transformation*	*Application to two DOF system*	*Application to slider crank mechanism*
S-6	SLO-1	*Spherical joint*	*Joint forces*	*Rigid body displacement*	*Constraint equations for cams and followers*	*Prescribed rotation of crank shaft*
	SLO-2	*Higher pairs*	*External forces*	*Position equations*	*Constraint equations for gears*	*Prescribed rotation of slider bock*
S-7	SLO-1	*Cam and gear systems*	*Principle of virtual work*	*Velocity equations*	*Computational methods in kinematics*	*Constrained dynamics*
	SLO-2	*Four bar mechanism*	*Use of redundant system*	*Acceleration equations*	*Kinematically driven systems*	*Augmented formulation*
S-8	SLO-1	*Slider crank mechanism*	*Forward dynamics*	*Slider crank mechanism*	*Velocity analysis*	*Embedding technique*
	SLO-2	*Closed chain systems*	*Inverse dynamics*	*Offset slider crank mechanism*	*Computer implementation to simple four bar mechanism*	*Amalgamated formulation*
S-9	SLO-1	*Open chain systems*	*Planar dynamics*	*Singular configuration*	*Computer implementation to simple four bar mechanism*	*Open and closed chains*
	SLO-2	*Robotic manipulators*	*Spatial dynamics*	*Four bar mechanism*	*Numerical based on four bar mechanism*	*Open and closed chains*

Learning Resources	1. *Ahmed A Shabana., "Computational Dynamics ", third edition, Wiley & Sons* 2. *Fundamentals of multibody dynamics : theory and applications, first edition, FaridAmirouche*	3. *Kinematic and dynamic simulation of multibody systems, first edition Garcia De Jalon* 4. *Dynamics of multibody systems by Ahmed A Shabana, third edition*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Franklin Darlie, HAL Frank_darlie@rediff.com	*1. Dr.D.Dinakaran HITS dinakaran@hindustanuniv.ac.in*	*1. Dr. K.Kamalakkannan SRMIST kamalakk1@srmist.edu.in*
2. Mr.V.Raja Raman Altair rajarav@asiapac.altair.com	*2. Dr. R Kannan, PSNA Kannanjothy@gmail.com*	*2. Mr.S.SenthilKumar, SRMIST senthils6@srmist.edu.in*

Course Code	18AUE443T	Course Name	FINITE ELEMENT ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18MEC106T*	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 multibody systems*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply finite element technique to Engineering problems*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*H*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Improve their ability in solving differential equations for real world problems*	*2*	*70*	*60*	*H*	*H*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-3 :	*Equip themselves familiar with multi-domain phenomenon like thermo-structural problems*	*1*	*80*	*70*	*M*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-4 :	*Familiarize themselves with the applications of finite element method & FEA packages*	*3*	*90*	*90*	*M*	*H*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-5 :	*Solve kinematic and dynamic problems of multibody systems*	*2*	*70*	*60*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*H*	*M*	*M*	*L*	*M*	*H*	*M*	*M*

Duration (hour)		History and basics of FEA	One dimensional Problems	Two dimensional Problems	Multidomain Problems	Applications of FEA
		9	9	9	9	9
S-1	SLO-1	*Comparison Of FEA With Exact Solutions*	*Elements and node numbering*	*Two dimensional elements*	*Vibration analysis introduction*	*Introduction and basics*
	SLO-2					
S-2	SLO-1	*Methods of engineering analysis*	*Global and local co-ordinates*	*Plane stress formulation*	*Vibration analysis introduction*	*Roll cage analysis*
	SLO-2	*Numerical methods*	*Natural co-ordinates*	*Plane strain formulation*	*Modal analysis of a structure*	*Roll cage analysis*
S-3	SLO-1	*Types of finite elements*	*Polynomial functions*	*CST element*	*Modal analysis of a structure*	*Rotor thermal analysis*
	SLO-2	*Displacement or shape function*	*Displacement function for 1D bar element*	*Shape function derivation for CST element*	*fluid flow problems*	*Rotor thermal analysis*
S-4	SLO-1	*Material behavior*	*General stiffness matrix derivation*	*Strain displacement matrix for CST element*	*fluid flow problems*	*Hub analysis*
	SLO-2	*Stiffness matrix*	*Stiffness matrix for 1D bar element*	*Stress strain matrix for CST element*	*fluid flow problems*	*Knuckle analysis*
S-5	SLO-1	*Steps involved in FEA –preprocessing and solution*	*Assembly of stiffness matrix*	*Stiffness matrix derivation for CST element*	*Heat transfer problems*	*Brake pedal analysis*
	SLO-2	*Post processing*	*Force vector*	*Temperature effects*	*Heat transfer problems*	*Brake pedal analysis*
S-6	SLO-1	*2D and 3D stress element*	*Spring element*	*LST element*	*Heat transfer problems*	*Bump analysis*
	SLO-2	*Strain-displacement relationships*	*Stiffness matrix for spring element*	*QST element*	*Heat transfer problems*	*Bump analysis*
S-7	SLO-1	*Discretization methods*	*Boundary conditions*	*Axi –symmetric formulation*	*Thermo structural analysis*	*Multbodydynamics applications*
	SLO-2	*Discretization process*	*Imposing boundary conditions to bar element*	*Isoparametric formulation*	*Thermo structural analysis*	*Forward and Inverse dynamics*
S-8	SLO-1	*Rayleigh ritz method*	*Beam element*	*Iso, sub. Super parametric element formulation*	*Thermo structural analysis*	*Planar dynamics*
	SLO-2	*Galerkin method*	*Stiffness matrix derivation of beam element*	*Four noded quadrilateral element*	*Thermo structural analysis*	*Spatial dynamics*
S-9	SLO-1	*Advantages and disadvantages of FEA*	*Truss element*	*1D heat conduction problems*	*Introduction to biomedical and MEMS applications*	*Application Of MBD Technique To Four-Bar Mechanisms*
	SLO-2	*Applications of FEA*	*Stiffness matrix for truss element*	*Derivation of stiffness matrix*	*Introduction to biomedical and MEMS applications*	*Application Of MBD Technique Slider Crank Mechanisms*

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.third edition*	3. *Bhavikatti S.S., "Finite Element Analysis", New Age International Publishers, New Delhi, 2008.* 4. *ErdoganMadenci, Ibrahim Guven, "the finite element method and applications in engineering using ansys", Springer (India) Private Limited, New Delhi, 2011.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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. K.Kamalakkannan SRMIST kamalakk1@srmist.edu.in*
2. Mr.V.Raja Raman Altair rajarav@asiapac.altair.com	*2. Dr.M.Rajesh, Arbaminch institute of technology Rajesh.m@amu.edu.et*	*2. Mr.S.SenthilKumar, SRMIST senthils6@srmist.edu.in*

Course Code	18AUE444T	Course Name	DESIGN OF EXPERIMENTS	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Give Insights about Design of experiments			
CLR-2 :	Illustrate Full factorial design experiments			
CLR-3 :	Familiarize DOE statistical analysis			
CLR-4 :	Illustrate Fractional factorial design experiments			
CLR-5 :	Analyse response surface methodology for DOEs			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	Students gain knowledge and expertise in the field of electrical and electronics	Ability to understand recent technological developments in Automotive electronics and develop products to cater the societal and	Assess society needs and develop constructive and creative solutions for problems related to
CLO-1 :	Describe about design of experiments	1	85	80	H	M	H	M	L	M	M	H	M	H	H	H	H	H	H
CLO-2 :	Demonstrate full factorial design experiments	2	80	75	H	M	M	L	L	M	M	M	H	H	L	H	H	H	H
CLO-3 :	Analyse regression equation and random error plot	3	85	80	H	H	H	H	H	M	H	M	M	M	H	H	H	H	H
CLO-4 :	Interpret Full and Fractional factorial design experiments	2	80	75	H	H	H	H	M	M	M	M	M	M	M	H	H	H	H
CLO-5 :	Develop Response surface methodology	3	85	80	H	H	H	H	H	M	H	M	M	M	H	H	H	H	H

Duration (hour)		Overview of DoE and its requirements	Full Factorial Experiments	DOE Statistical Analysis	Fractional (Partial) Factorial Experiments	Robust Design Experiments and Response Surface Modelling
		9	9	9	9	9
S-1	SLO-1	Overview of DoE and its requirements	Introduction to Full Factorial Experiments	Introduction to DOE Statistical Analysis	Introduction to Fractional (Partial) Factorial Experiments	Introduction to Robust Design Experiments and Response Surface Modelling
	SLO-2	Overview of DoE and its requirements	Introduction to Full Factorial Experiments	Introduction to DOE Statistical Analysis	Introduction to Fractional (Partial) Factorial Experiments	Introduction to Robust Design Experiments and Response Surface Modelling
S-2	SLO-1	Various statistical tools	Introduction to Cube Plots for 3-factor 2-level Experiments	ANOVA Principles for Simple Full Factorial Experiments and Statistics Basics	The Confounding Principle	Robustness, Control and Noise Factors
	SLO-2	Application and its Examples	Introduction to Cube Plots for 3-factor 2-level Experiments	ANOVA Principles for Simple Full Factorial Experiments and Statistics Basics	The Confounding Principle	Robustness, Control and Noise Factors
S-3	SLO-1	DOE Fits in with Other Tools	Introduction to Cube Plots for 4-factor 2-level Experiments	Significance Test Methods	Fractional factorial design, Saturated Designs and Central composite designs.	Classical and Taguchi Robust DOE Set-Up
	SLO-2	DOE Fits in with Other Methods	Introduction to Cube Plots for 4-factor 2-level Experiments	Significance Test Methods	Fractional factorial design, Saturated Designs and Central composite designs.	Classical and Taguchi Robust DOE Set-Up
S-4	SLO-1	Writing Problem and Objective Statements	Experiment Set-Up	Effect of Non-Random Experiments	Reliability Improvement through experiments	Robustness Metrics, Analytical and Graphical Output Interpretation
	SLO-2	Writing Problem and Objective Statements	Experiment Set-Up	Effect of Non-Random Experiments	Reliability Improvement through experiments	Robustness Metrics, Analytical and Graphical Output Interpretation
S-5	SLO-1	Ensuring DOE is the Correct Tool	Factor Levels and Repetitions	Estimating Significance Test "Power" and Confidence Intervals	choice of sample size and Concept of confidence level	Response Surface Models (Plackett-Burman, Box-Behnken, etc.)

Duration (hour)		Overview of DoE and its requirements	Full Factorial Experiments	DOE Statistical Analysis	Fractional (Partial) Factorial Experiments	Robust Design Experiments and Response Surface Modelling
		9	9	9	9	9
	SLO-2	*Ensuring DOE is the Correct Tool*	*Factor Levels and Repetitions*	*Estimating Significance Test "Power" and Confidence Intervals*	*choice of sample size and Concept of confidence level*	*Response Surface Models (Plackett-Burman, Box-Behnken, etc.)*
S-6	SLO-1	*Selecting Response Variable(s) and Experimental Factors*	*"Right-Sizing" the Experiment*	*Estimating Random Error Analysis Plots - Normal and Half-Normal Plots*	*Selecting Generators (Identities) to Set Up Confounding Strings*	*Ideal Situation(s) to Use Each Response Surface DOE Type*
	SLO-2	*Actual vs. Surrogate Responses*	*"Right-Sizing" the Experiment*	*Estimating Random Error Analysis Plots - Normal and Half-Normal Plots*	*Selecting Generators (Identities) to Set Up Confounding Strings*	*Ideal Situation(s) to Use Each Response Surface DOE Type*
S-7	SLO-1	*Attention to Experiment Logistics*	*Experiment Terms to Estimate Main Effects*	*Main Effect and Interaction Plots*	*Using Generators (Identities) to Set Up Confounding Strings*	*Cube Plot Set-up of Each Response Surface DOE*
	SLO-2	*Attention to Experiment Logistics*	*Experiment Terms to Estimate Main Effects*	*Main Effect and Interaction Plots*	*Using Generators (Identities) to Set Up Confounding Strings*	*Cube Plot Set-up of Each Response Surface DOE*
S-8	SLO-1	*Test Set-up and Data Collection Planning*	*Experiment Terms to Estimate Interactions*	*Regression Analysis of Simple Full Factorial Experiments*	*Determining various Factor Combinations to Run*	*Analyzing Response Surface Experiment Data, Methods for Finding Optimum Factor Values*
	SLO-2	*Test Set-up and Data Collection Planning*	*Experiment Terms to Estimate Interactions*	*Regression Analysis of Simple Full Factorial Experiments*	*Determining various Factor Combinations to Run*	*Analyzing Response Surface Experiment Data, Methods for Finding Optimum Factor Values*
S-9	SLO-1	*Selecting and Evaluating a Gage*	*Experiment Terms to Estimate High-Level Significance Evaluation*	*Demonstrating Minitab™ for Full Factorial DOE Experiments*	*Analyzing Fractional Factorial Experiment Data ,Using MiniTab™ for Fractional Factorial Experiments*	*Demonstrating Minitab-TM for response Surface Experiments*
	SLO-2	*Selecting and Evaluating a Gage*	*Experiment Terms to Estimate High-Level Significance Evaluation*	*Demonstrating Minitab™ for Full Factorial DOE Experiments*	*Analyzing Fractional Factorial Experiment Data ,Using MiniTab™ for Fractional Factorial Experiments*	*Demonstrating Minitab-TM for response Surface Experiments*

Learning Resources	
1. S. SingaresuRao, "Engineering Optimization – Theory & Practice", New Age International (P) Limited, New Delhi, 2016. 2. D.K. PratiharNarosa , "Soft Computing: Fundamentals and Applications", Publishing House, New-Delhi, 2014	3. Kalyanamoy Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall of India Pvt. 2012. 4. Goldberg, D.E., "Genetic algorithms in search, optimization and machine", Barnen, Addison- Wesley, New York, 2008.

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	*30%*	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	*40%*	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. R. Rajasekar, RAMBAL, raj@rambalindia.net	*1. Dr. M. Rajesh, Arba Minch Institute of Technology, rajesh.m@amu.edu.et*	*1.Mr.*G.NARESH*, SRMIST, nareshg@srmist.edu.in*
2. Mr. V. Raja Raman, Altair, rajarav@asiapac.altair.com	*2. Dr. P.D. Jeyakumar, Crecent University, pdjeyakumar@cresent.education*	*2.Dr.*Kamalakannan*,SRMIST, kamalakk1@srmist.edu.in*

Course Code	18AUE445T	Course Name	PRODUCT LIFE CYCLE MANAGEMENT	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 :	Impart knowledge on explaining the history, concepts and terminology of PLM.
CLR-2 :	Applying the functions and features of PLM/PDM
CLR-3 :	Applying different modules offered in commercial PLM/PDM tools
CLR-4 :	Implementing PLM/PDM approaches for industrial applications
CLR-5 :	Integrating PLM/PDM with legacy data bases, CAX& ERP systems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Explain the history, concepts and terminology of PLM	1,2	90	85	H	M	H	H	H	M	M	L	M	M	L	M	H	H	H
CLO-2 :	Apply the functions and features of PLM/PDM	1,2	90	85	H	M	H	H	H	L	L	L	M	M	L	M	H	H	H
CLO-3 :	Apply different modules offered in commercial PLM/PDM tools	1,2	90	80	H	M	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-4 :	Implement PLM/PDM approaches for industrial applications.	1,2	80	75	H	H	H	H	H	L	L	L	M	M	L	L	H	H	H
CLO-5 :	Integrate PLM/PDM with legacy data bases, CAx& ERP systems	1,2	90	85	H	H	H	H	M	L	L	L	M	M	L	M	H	H	H

Duration (hour)		Introduction to PLM	PLM/PDM Functions and Features	Details of Modules in a PDM/PLM SOFTWARE	Role of PLM in Industries	Basics on Customization/Integration of PDM/PLM Software
		9	9	9	9	9
S-1	SLO-1	Introduction to PLM	User Functions	Modules in a PDM/PLM SOFTWARE	PLM selection and implementation	PLM Customization
	SLO-2	Need for PLM	User Functions		PLM selection and implementation	
S-2	SLO-1	opportunities of PLM	Data Vault and Document Management	Case studies based on top few commercial PLM/PDM tools	Auto, aero, electronic sectors	Use of EAI technology (Middleware)
	SLO-2	Different views of PLM			Auto, aero, electronic sectors	
S-3	SLO-1	Engineering Data Management (EDM)	Workflow and Process Management	Case studies based on top few commercial PLM/PDM tools	Role of PLM in Other possible sectors	Different ways to integrate PLM systems
	SLO-2	Engineering Data Management (EDM)			Role of PLM in Other possible sectors	Different ways to integrate PLM systems
S-4	SLO-1	Product Data Management (PDM)	Product Structure Management	Teamcenter	PLM visioning	Transfer file integration
	SLO-2		Product Structure Management	Windchill	PLM strategy	Advantages and disadvantages of Transfer file integration
S-5	SLO-1	Collaborative Product Definition Management (CPDM)	Product Classification	ENOVIA	PLM feasibility study	Middleware integration
	SLO-2	Collaborative Product Definition Management (CPDM)	Product Classification and Programme Management	Aras PLM		Advantages and disadvantages of Middleware integration
S-6	SLO-1	Collaborative Product Commerce (CPC)	Utility Functions	SAP PLM	Change management for PLM	Database integration
	SLO-2	Collaborative Product Commerce (CPC)	Utility Functions	SAP PLM	Change management for PLM	Advantages and disadvantages of Database integration
S-7	SLO-1	Product Lifecycle Management (PLM).	Communication and Notification	Arena,	financial justification of PLM	System roles
	SLO-2	PLM/PDM Infrastructure	data transport	Oracle Agile PLM	barriers to PLM implementation	ERP and Modules
S-8	SLO-1	Network and Communications, Data Management	data translation	Autodesk Vault	Ten step approach to PLM	Support of PLM and ERP in the business processes
	SLO-2		image services	Standards of PLM	Benefits of PLM for–business, organization	CAD and configurators

Duration (hour)		Introduction to PLM	PLM/PDM Functions and Features	Details of Modules in a PDM/PLM SOFTWARE	Role of PLM in Industries	Basics on Customization/Integration of PDM/PLM Software
		9	9	9	9	9
S-9	SLO-1	, Heterogeneous data sources and applications	system administration and application integration	Standards of PLM	Benefits of PLM for–, users, product or service	EAI and SLM
	SLO-2				process performance	Integration with legacy data base

Learning Resources	1. AnttiSaaksvuori and AnselmiImmonen., "Product Lifecycle ManagementSpringer Publisher. 2008. 2. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill; 10 edition 2006. 3. ArieKarniel and Yoram Reich., "Managing the Dynamics of New Product Development Processes: A New Product Lifecycle Management Paradigm".,Springer,2011	4. IvicaCrnkovic, Ulf Asklund and AnnitaPerssonDahlqvist., Implementing and Integrating Product Data Management and Software Configuration Management".,DelmarCengage Learning; 4th edition edition, 2011 5. ManJohn Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007 6. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011.

2

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	70 %	-	60 %	-	60 %	-	50 %	-	50 %	-
	Understand										
Level 2	Apply	30 %	-	40 %	-	40 %	-	40 %	-	40 %	-
	Analyze										
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.N.Vijayakumar, Head Test labs, Mahindra and Mahindra, VIJAYAKUMAR.N@mahindra.com.	1. Prof. M.Balasubramanian, Professor, IIT Madras, mbala@iitm.ac.in	1. Dr. K. Kamalakkannan SRMIST, kamalakk1@srmist.edu.in.
2. Mr.Prasad Arun Kumar, Mahindra Research Valley, prasad.arunkumar@mahindra.com	2. Dr.P.Jawahar, Assistant Professor, NIT Agartala, drjawahar.me@nita.ac.in	2. Mr.K.Devanathan, SRMIST, devanatk@srmist.edu.in

Course Code	18AUE351T	Course Name	AUXILIARY VEHICLE SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC302J*	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:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	*Recognize the vehicle motion control and stabilization system*																		
CLR-2 :	*Identify the importance of Driver assistance, security and warning system*																		
CLR-3 :	*Buildthe knowledge of Safety and comfort system*																		
CLR-4 :	*Understand the auxiliary systems of chassis.*																		
CLR-5 :	*Assess the automotive Safety System*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand the vehicle motion control and stabilization system*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*L*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-2 :	*Know the importance of Driver assistance, security and warning system*	*2*	*85*	*80*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*H*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-3 :	*Know the working of the compartment while moving of the vehicle, about the collapsible steering and tillable steering column, about the collision avoidance system, front and rearObject detection.*	*2*	*85*	*80*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*H*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-4 :	*Understand the auxiliary systems of chassis.*	*2*	*85*	*80*	*H*	*M*	*H*	*H*	*L*	*L*	*L*	*L*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-5 :	*Know the various types of safety aspects such as active and passive safety, the active safety components and the working passive safety components such as air bags, seat belts*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*H*	*L*	*L*	*L*	*H*	*M*	*H*

Duration (hour)		Vehicle Motion Control and Stabilization System	Information, Security and Warning System	Comfort Systems	Chassis Auxiliary System	Safety System
		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Vehicle integration*	*Heating, Ventilation*	*Needs for Auxiliary systems*	*Seat belt, Seat belt tightener system and importance.*
	SLO-2	*Introduction*	*Vehicle integration*	*Heating, Ventilation*	*Needs for Auxiliary systems*	*Seat belt, Seat belt tightener system and importance.*
S-2	SLO-1	*Antilock braking system,*	*And navigation system*	*And Air Conditioning Systems*	*Power Assisted Steering System*	*Collapsible Steering Column,*
	SLO-2	*Stability Control*	*Looking out sensors*	*Principles and working*	*Working principle*	*Air Bags Deployment System*
S-3	SLO-1	*Adaptive cruise control*	*And Looking in sensors,*	*Electronic Outside Rear View Mirror (OVRM)*	*Regenerative Braking System*	*Designing aspects of automotive bumpers*
	SLO-2	*Lane Keep Assist System*	*Intelligent vision system,*	*Rain Sensing Wiper System*	*Principle and operation*	*Designing aspects of automotive bumpers*
S-4	SLO-1	*CollisionWarning*	*Vehicle Integration system.*	*Environment Information System*	*Servo Brake*	*Materials for bumpers.*
	SLO-2	*avoidance system,*	*Global Positioning System.*	*Tilt Able Steering Wheel,*	*Servo Brake*	*Materials for bumpers.*
S-5	SLO-1	*Blind Spot Detection system,*	*Vehicle Navigation System.*	*Garage Door Opening System*	*Vehicle Retarders*	*Steering and mirroradjustment,*
	SLO-2	*Blind Spot Detection system,*	*Road Network*	*Automatic Climate Control*	*Electrical retarders*	*Frontal Object Detection*
S-6	SLO-1	*Driver alertness detection system*	*Onboard Diagnosis System*	*Adaptive Head Light*	*Hydrodynamic retarders*	*Rear Vehicle Object Detection System*
	SLO-2	*Driver alertness detection system*	*Immobilizer*	*Night Vision Assist,*	*Advantages of retarders*	*Anti-roll bar*
S-7	SLO-1	*Electronic Transmission Control System*	*Anti-Theft Alarm System*	*Traffic Jam Assist*	*Hydro Elastic Suspension System*	*Emergency Brake Assist,*
	SLO-2	*Working principle*	*Voice Warning System*	*Hill Start Assist*	*Hydro Elastic Suspension System*	*Emergency Response*
S-8	SLO-1	*Electronic Brake Force Distribution System*	*Keyless Entry System*	*Need for Active suspension*	*Rubber Suspension*	*Child Lock System*

Duration (hour)		Vehicle Motion Control and Stabilization System	Information, Security and Warning System	Comfort Systems	Chassis Auxiliary System	Safety System
		9	9	9	9	9
	SLO-2	*Electronic Brake Force Distribution System*	*Central Locking System*	*Need for Active suspension*	*Pneumatic Suspension*	*Child Lock System*
S-9	SLO-1	*Tutorial*	*Tire Pressure Monitoring System*	*Construction of active suspension*	*Drive By Wire System*	*Central locking system*
	SLO-2	*Tutorial*	*Tire Pressure Monitoring System*	*Working of active suspension*	*Brake by wire*	*Central locking system*

Learning Resources	1. *William B. Ribbens, "Understanding Automotive Electronics", 6th Edition, Newnes, 2003.* 2. *Robert N Brady "Automotive computers and Digital Instrumentation". A Reston Book, Prentice Hill, Eagle Wood Cliffs, New Jersey, 1988.* 3. *Ronald.K.Jurgen-"Automotive Electronics Handbook"-Second edition- McGraw -Hill Inc., -1999.*	4. *Dr. Kirpal Singh, "Automobile Engineering" Volume – 1, 12th Edition, Standard Publishers* 5. *BOSCH, Automotive Handbook, 6th Edition, Bentley publishers* 6. *Robert Bosch GmbH -"Safety, Comfort and Convenience Systems"-Wiley; 3rd edition, 2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.MyilavanPalanivel, WABCO India limited ,myilavan@gmail.com	*1. Dr.R.Ben Ruben, Sri Krishna College of Engineering and Technology, benrubenr@skcet.ac.in.*	*1. Mr,S.Devanand, SRMIST*
2. Mr.SureshMekalathuru, WABCO India limited, sureshme305@gmail.com	*2. Dr.S.Ramkumar, Vel Tech, drsramkumar@veltech.edu.*	*2. Dr. Edwin Geo V, SRMIST*

Course Code	18AUE352T	Course Name	TWO AND THREE WHEELER TECHNOLOGY	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 :	*Impart knowledge on power plant and different systems in two wheelers*
CLR-2 :	*Know the arrangement of chassis in two wheelers and subsystems like transmission and suspension*
CLR-3 :	*Identify different brakes used in two wheelers and construction of wheels and tires*
CLR-4 :	*Understand Servicing, maintenance and troubleshooting techniques particularly for two wheelers*
CLR-5 :	*Gain knowledge on different types of three wheelers, pickup and delivery vans arrangements*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Classify the different power plants and systems arrangement of petrol and electric vehicles*	*1,2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-2 :	*Distinguish chassis and transmission systems arrangements in two wheelers*	*1,2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Classify different brakes and tires used in two wheelers and their applications*	*1,2*	*90*	*80*	*H*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-4 :	*Gain knowledge on different servicing and troubleshooting techniques and case studies of two wheelers*	*1,2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-5 :	*Infer different types of three wheeler arrangements for different applications and case studies on recent models*	*1,2*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*

Duration (hour)		Power plant	Chassis and sub systems	Brakes and wheels	Servicing, Maintenance, Trouble Shooting and Case Study of Major Indian Models	Three wheelers
		9	9	9	9	9
S-1	SLO-1	*Power plant components*	*Chassis and sub systems-components*	*Brakes-introduction*	*Servicing-Introduction*	*Three wheelers-types*
	SLO-2	*Two stroke and four stroke SI engines - merits and demerits*	*Types of main frames.*	*Braking systems*	*Service procedure for two wheelers*	*Case study of Indian models*
S-2	SLO-1	*Symmetrical and unsymmetrical port timing diagram*	*Drive from engine to rear wheel*	*Drum brakes-principle, construction and working*	*Service procedure for two wheelers*	*Case study of Indian models*
	SLO-2	*Valve timing diagram.*	*chain drive – shaft drive*	*Disc brakes-principle, construction and working*	*Petrol engine tune up*	*Front engine auto rickshaws*
S-3	SLO-1	*Types of scavenging processes – merits and demerits.*	*Clutch requirements*	*Brake links layout – for front wheels – for rear wheels*	*Petrol engine tune up*	*Front engine auto rickshaws*
	SLO-2	*Scavenging efficiency, scavenging pumps*	*Single plate – multiple plates – centrifugal clutch.*	*Brake adjustment*	*Petrol engine tune up*	*Rear engine auto rickshaws*
S-4	SLO-1	*Fuel systems*	*Transmission (gear box)*	*Need of ABS for two wheelers*	*Preventive and scheduled maintenance in two wheelers*	*Rear engine auto rickshaws*
	SLO-2	*Carburetion, gasoline fuel injection systems. Lubrication systems.*	*gear controls and gear change mechanism*	*Single channel and dual channel ABS*	*Preventive and scheduled maintenance in two wheelers*	*Pickup vans*
S-5	SLO-1	*Ignition system – magneto coil spark ignition system*	*CVT for two wheelers*	*Wheels*	*Troubleshooting and maintenance of two-wheeler transmission*	*Delivery vans*
	SLO-2	*battery coil spark ignition system, electronic ignition system*	*Suspension*	*spokes wheel – cast wheel – disc wheel*	*Troubleshooting and maintenance of two-wheeler transmission*	*Trailers*
S-6	SLO-1	*Starting systems*	*Suspension – for front wheels*	*Tires*	*Troubleshooting of brakes and wheels*	*frames and transmission*
	SLO-2	*Kick starter and electrical systems.*	*Suspension – for rear wheels*	*Tire construction*	*Troubleshooting of brakes and wheels*	*frames and transmission*

Duration (hour)		Power plant	Chassis and sub systems	Brakes and wheels	Servicing, Maintenance, Trouble Shooting and Case Study of Major Indian Models	Three wheelers
		9	9	9	9	9
S-7	SLO-1	*Electric scooter power plant*	*Telescopic and gas charged suspension*	*Tube and tubeless tires*	*Servicing and case study of major Indian models*	*wheel types*
	SLO-2	*Different types of batteries for electric scooters*	*Shock absorbers*	*Radial ply and cross ply tires*	*Servicing and case study of major Indian models*	*wheel mountings attachment*
S-8	SLO-1	*Different traction motors*	*Panel meters and controls on handle bar*	*Tubes – vulcanizing.*	*Case study of Electric scooters*	*Tyre types.*
	SLO-2	*Different traction motors*	*Panel meters and controls on handle bar*	*Tire requirements of electric vehicles*	*Case study of Electric scooters*	*Brake systems.*
S-9	SLO-1	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
	SLO-2	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*

Learning Resources	
1. *K.K. Ramalingam., "Two wheelers", Scitech Publications (India) Pvt. Ltd., Chennai 2012.* 2. *William H crouse, "Automotive Mechanics", McGraw Hill Education; 10 edition 2017*	3. *Irving, P.E., "Motor cycle Engineering"., Veloce Enterprises, Inc.2017* 4. *Tim Gilles., "Automotive service".,Delmar Cengage Learning; 4th edition edition, 2011* 5. *Manufacturers manual of various vehicles*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*70 %*	-	*60 %*	-	*60 %*	-	*50 %*	-	*50 %*	-
	Understand										
Level 2	Apply	*30 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-
	Analyze										
Level 3	Evaluate	-	-	-	-	-	-	-	-	-	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.K.V. Simmom, Royal Enfield, kvsimmon1@royalenfield.com	*1. Dr..A.Samuel Raja, Thiyagarajar college of Engineering Madurai, samuel1973@tce.edu*	*1. Dr.V.Edwin Geo, SRMIST*
2. Mr.R.Srikanth, Altair, srikanth.r@altair.com	*2. Mr. N.Ravikumar, Crescent Institute of Science and Technology, ravikumar@crescent.education*	*2. Mr.K.Devanathan, SRMIST*

Course Code	18AUE353T	Course Name	VEHICLE PERFORMANCE AND TESTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC302J*	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 about the various parameters that influence the performance of vehicles*
CLR-2 :	*Understand the engine performance characteristics and match with transmission related requirements*
CLR-3 :	*Learn about various vehicle tests conducted.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Determine the parameters influencing vehicle performance and predict the performance*	*2*	*90*	*75*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-2 :	*Diagnose the various engine sub systems for improving engine performance*	*2*	*80*	*80*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-3 :	*Analyze the performance characteristics of transmission, braking and suspension systems*	*3*	*85*	*80*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-4 :	*Study the operational performance of vehicles*	*1*	*90*	*85*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*H*	*L*	*H*
CLO-5 :	*Acquire knowledge about the various vehicle testing methods*	*2*	*85*	*80*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*L*	*L*	*L*	*M*	*H*	*L*	*H*

Duration (hour)		Vehicle performance estimation and prediction	Engine performance diagnosis	Vehicle Transmission and control system performance	Operational performance	Vehicle Testing
		9	9	9	9	9
S-1	SLO-1	*Estimate the aerodynamic drag of road vehicles*	*List the reasons for engine leakage*	*Identify the causes of clutch slippage and drag*	*Restate the engine performance parameters*	*Review the fundamentals of acoustics*
	SLO-2	*List the methods of estimation of resistance to vehicle motion*	*Discuss the cylinder leakage test*	*Identify the causes of clutch vibration*	*Discuss the operating characteristics of engines*	*Discuss the human response to sound*
S-2	SLO-1	*List the parameters involved in calculating power required for propulsion*	*Determine and locate the sources of engine noise*	*Recall the working of automatic transmission systems*	*Study the operation of engine at full load conditions*	*Explain the testing procedure for vehicle power*
	SLO-2	*Calculate the power required for propulsion*	*Suggest the methods of reducing noise from the various sources*	*Analyze the performance of automatic transmission systems*	*Study the operation of engine at part load conditions*	*Explain the testing procedure for evaluating fuel consumption*
S-3	SLO-1	*Analyze the power plant characteristics of vehicles*	*Interpret engine oil issues that affect engine performance*	*Analyze the performance of bands*	*Recall the various parameters influencing fuel economy*	*Explain the head light alignment testing*
	SLO-2	*Compare the power plant characteristics with the requirements of transmission system of vehicles*	*Analyze the effect of temperature and its measurement on engine performance*	*Analyze the performance of transmission fluids*	*Predict the influence of various parameters influencing fuel economy*	*Explain the light intensity testing*
S-4	SLO-1	*Study about the various vehicle controls*	*Identify the symptoms of cooling system failure*	*Describe the solenoid valve testing method*	*Recite the various conditions of vehicle running*	*Explain the road testing of vehicles*
	SLO-2	*Sketch the different arrangements in power train configuration*	*Diagnose the cooling system*	*Describe the diagnostic procedure for testing of driveline components*	*Discuss the effects of vehicle conditions on fuel economy*	*Classify and study the different test tracks for vehicle testing*
S-5	SLO-1	*Calculate the vehicle acceleration and maximum speed of vehicles*	*Identify the weak cylinder through power balance test*	*Categorize the various braking arrangements*	*Recall the various tyre and road conditions a vehicle is subjected to*	*Describe the initial inspection procedure in vehicle testing*
	SLO-2	*Estimate the grade ability performance of vehicles*	*Conduct compression test and identify the reasons for power loss*	*Analyze the performance and characteristics of braking systems*	*Predict the effect of various tyre and road conditions on fuel economy*	*Describe the PDI procedure in vehicle testing*

Duration (hour)		Vehicle performance estimation and prediction	Engine performance diagnosis	Vehicle Transmission and control system performance	Operational performance	Vehicle Testing
		9	9	9	9	9
S-6	SLO-1	*List the various drive system of vehicles*	*Understand valve timing test*	*Predict the effect of weight transfer in vehicles*	*List the various traffic conditions*	*Explain the maximum speed estimation procedure*
	SLO-2	*Compare the various drive systems for vehicle requirements*	*Understand clearance test*	*Diagram the various steering system arrangements*	*Study the effect of various traffic conditions and driving habits on fuel economy*	*Explain the maximum acceleration estimation procedure*
S-7	SLO-1	*Study the hill climbing requirements*	*Estimate the intake system performance*	*Evaluate the performance of rigid suspension system*	*Recall the definition of turning circle radius of a vehicle*	*Quote the principles of brake testing of road vehicles*
	SLO-2	*Characterize the vehicle power requirements for hill climbing*	*Estimate the exhaust system performance*	*Analyze the characteristics of rigid suspension system*	*Formulate the turning circle radius test of a vehicle*	*Explain the procedure of brake testing of road vehicles*
S-8	SLO-1	*Define ride characteristics of vehicles*	*Estimate the boost pressure available from a turbocharger*	*Evaluate the performance of independent suspension system*	*Describe the testing of vehicles in a two-wheeler chassis dynamometer*	*Review the basic concepts of vehicle handling*
	SLO-2	*Study the ride characteristics of vehicles on different road surfaces*	*Analyze the effect of waste gate on boost pressure*	*Analyze the characteristics of independent suspension system*	*Evaluate the performance of vehicles in a two-wheeler chassis dynamometer*	*Evaluate the handling characteristics of vehicles on different road surfaces*
S-9	SLO-1	*Analyze the effect of pressure and temperature on power output*	*List the steps in no start diagnosis*	*Evaluate the performance of torsion bar, stabilize and radius bars*	*Describe the testing of vehicles in a four-wheeler chassis dynamometer*	*Review the basic concepts of side slip*
	SLO-2	*Analyze the effect of humidity on power output*	*Explain the scope testing of ignition systems*	*Analyze the characteristics of torsion bar, stabilize and radius bars*	*Evaluate the performance of vehicles in a four-wheeler chassis dynamometer*	*Explain the side slip determination method*

Learning Resources	
1. *Martyr A.J, Plint M.A, Engine Testing Theory and Practice", 3rd edition, Butter worth-Heinemann, 2007. Butterworth - Heinemann, 2007.*	3. *Gousha H. M, "Engine Performance Diagnosis & Tune Up Shop Manual".*
2. *Ken Pickerill, "Automotive Engineering Engine Performance Shop Manual", Cengage Learning, 2010*	4. *Crouse. W. H, Anglin. D. L, "Motor Vehicle Inspection", McGraw Hill, 1978.*
	5. *Giles J. G, "Vehicle Operation & Performance".*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.K.V. Simmom, Royal Enfield, kvsimmon1@royalenfield.com	*1. Dr..A.Samuel Raja,Thiyagarajar college of Engineering Madurai, samuel1973@tce.edu*	*1. Dr. V. Edwin Geo, SRMIST*
2. Mr. Palla Lokesh, Mhaindra & Mahindra, lokeshpalla@mahindra.com	*2. Dr.R Sakthivel, Sri Venkateswara College of Engineering ,rsakthivel@svce.ac.in*	*2. Mr. A.J.D. Nanthakumar SRMIST*

Course Code	18AUE354T	Course Name	TYRE TECHNOLOGY	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 :	*Provide a broad overview of the basic aspects of the design, materials and operation of pneumatic vehicle tyres*
CLR-2 :	*Understand the engine performance characteristics and match with transmission related requirements*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand tyre design processes and its testing*	*2*	*90*	*85*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Know about pneumatic tyre applications in various vehicles*	*2*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*H*	*H*	*H*
CLO-3 :	*Understand the forces and moments acting on the vehicle.*	*3*	*90*	*85*	*H*	*H*	*H*	*M*	*H*	*L*	*H*	*H*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-4 :	*Evaluate various tyre analysis procedure*	*1*	*90*	*85*	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
CLO-5 :	*Know the tyre measurement techniques*	*2*	*90*	*85*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*L*	*H*	*L*	*L*	*M*	*M*	*M*

Duration (hours)		Overview of tyre technology	Applications of Pneumatic Tyres	Mechanics of Pneumatic Tyres	Tyre Analysis	Tyre Measurement Techniques
		9	9	9	9	9
S-1	SLO1	*Types-Diagonal- belted bias- radial bias*	*Bicycle Tyres*	*Tyre Axis system*	*Tyre Load Capacity*	*Tyre component Profilometer- Thickness control*
	SLO2					
S-2	SLO1	*Industry Standards*	*Two Wheeler – Castoring Trail for Motor cycle*	*Rolling Resistance – Variation of Rolling resistance coeffiecient of bias ply and radial ply tyres with speed*	*TRA Formula , Basic Formula*	*On roll profile thickness measurement*
	SLO2	*Tyre components – Radial Tyre*	*Two Wheeler – Internal heat generation*	*Rolling Resistance – variation with surface textures*	*Constant, Pressure exponent, Section Diameter.*	*On roll profile thickness measurement*
S-3	SLO1	*Tyre Design Process*	*Passenger Car Tyres – Tyre ground Contact area*	*Rolling Resistance – Effect of Tyre diameter*	*Deflection Analysis:*	*Dimension control – length measurement*
	SLO2	*Tyre Design Process*	*Passenger Car Tyres – contact area shape*	*Rolling Resistance – Effect of Tractive and Braking effort*	*Deflection Analysis:*	*Dimension Control – Width measurement*
S-4	SLO1	*Tyre performance criteria outdoor test – Wear rate, Irregular wear*	*Passenger Car Tyres – distribution of ground contact Pressure*	*Tractive Effort and Longitudinal Slip - Behaviour of Tyre under driving torque*	*Deflection Analysis:*	*Tyre piece weight measurement*
	SLO2	*Tyre performance criteria outdoor test - Handling Dry,Wet and Snow*	*Passenger Car Tyres - deflation – effects of run – flat*	*Tractive Effort and Longitudinal Slip - Variation of Tractive effort with longitudinal Slip*	*Deflection Analysis:*	*Tyre colour inspection*
S-5	SLO1	*Tyre performance criteria outdoor test - Ride comfort*	*Truck Tyres Design*	*Tractive Effort and Longitudinal Slip - Behaviour of Tyre under braking torque*	*Sliding Abraration, Tyre Stiffness and Tyre wear*	*Tyre Geometry inspection*
	SLO2	*Tyre performance criteria outdoor test – Noise, Drift/Pull*	*Truck Tyres Design*	*Tractive Effort and Longitudinal Slip - Variation of braking effort with longitudinal Slip*	*Sliding Abraration, Tyre Stiffness and Tyre wear*	*Tyre Geometry Inspection*
S-6	SLO1	*Tyre performance criteria indoor test – High speed*	*Truck Tyres – Tread patterns*	*Cornering Properties - slip angle and cornering force*	*Sliding Abraration, Tyre Stiffness and Tyre wear*	*Tyre Mark Inspection*
	SLO2	*Tyre performance criteria indoor test – Endurance*	*Truck Tyres – Tread patterns*	*Cornering Properties - cornering characteristics of bias and radial ply tyres for cars and trucks*	*Sliding Abraration, Tyre Stiffness and Tyre wear*	*Retrofit- Tyre Geometry line*

Duration (hours)		Overview of tyre technology	Applications of Pneumatic Tyres	Mechanics of Pneumatic Tyres	Tyre Analysis	Tyre Measurement Techniques
		9	9	9	9	9
S-7	SLO1	*Tyre performance criteria indoor test –Rolling resistance Vs Inflation*	*Truck Tyres – Tread compounds*	*Cornering Properties - Self aligning torque*	*Failure Analysis: Structural Failures*	*Retrofit- Tyre Uniformity line*
	SLO2	*Tyre performance criteria indoor test –Rolling resistance Vs Inflation*	*Truck Tyres – Tread Compounds*	*Cornering Properties – Variation of Self aligning torque with slip angle for bias and radial ply tyres*	*Failure Analysis: Structural Failures*	*Retrofit – Tyre balancing line*
S-8	SLO1	*Technical Test- Force and Moment Properties, Resistitvity, Uniformity*	*Tyres for Agricultural and Earth Movers*	*Cornering Properties – Camber and Camber Thrust*	*Failure Analysis: In service failure modes*	*Non Destructive Testing Methods*
	SLO2	*Technical Test-Flat spotting, Traction*	*Tyres for Agricultural and Earth Movers*	*Cornering Properties – Variation of Camber thrust with normal load and camber angle for car tyres*	*Failure Analysis: In service failure modes*	*X-ray Examination*
S-9	SLO1	*Tyre Manufacturing Process – Compound Preparation, Extrusion process*	*Tyres for Military Vehicle*	*Models for Cornering Behavior of tires - Stretched String model*	*Tyre durability, Servicing, maintenance and safety*	*Shearography*
	SLO2	*Tyre Assembly and Curing*	*Tyres for Military Vehicle*	*Models for Cornering Behavior of tires - Beam on Elastic foundation model*	*Tyre durability, Servicing, maintenance and safety*	*Eddy Current*

Learning Resources	*1. US Department of Transportation., "The Pneumatic Tire",February 2006* *2. Tom French, "Tyre Technology" Taylor and Francis 2007*	*3. J. Y. Wong, "Theory of Ground Vehicles", 4th Edition"2008* *4. H. B. Pacejka "Tyre and vehicle dynamics", Second Edition 2006*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory		Theory		Theory		Theory		Theory	
Level 1	Remember	*40%*		*40%*		*40%*		*40%*		*40%*	
	Understand										
Level 2	Apply	*40%*		*40%*		*40%*		*40%*		*40%*	
	Analyze										
Level 3	Evaluate	*20%*		*20%*		*20%*		*20%*		*20%*	
	Create										
	Total	100 %		100 %		100 %		100 %		100%	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jugeshdas, Apollo tyres jugesh.das@apollotyres.com	*1. Dr.V M Murugesan Vnm.auto@psgtech.ac.in*	*1.Dr.K.Kamalakkannan SRMIST kamalakk1@srmist.edu.in*
2. Mr.G.Giri Atalon giri@atalon.co.in	*2. Dr.K.Prabu VIT Prabu.k@vit.ac.in*	*2. Mr.S.Yokeshwaran, SRMIST yokeshws@srmist.edu.in*

Course Code	18AUE355T	Course Name	MOTORSPORT TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC302J*	Co-requisite Courses	*18AUC401J*	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:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-1 :	*Provide an insight on the problems imposed by racing, race car design and development strategies..*																		
CLR-2 :	*Understand the aerodynamic requirements in racing vehicles and the purpose of various aerodynamic devices.*																		
CLR-3 :	*Understand the behavior of a racing vehicle chassis at different conditions.*																		
CLR-4 :	*Gain knowledge about the concepts of various suspension characteristics of racing vehicles.*																		
CLR-5 :	*Understand the problems faced in drives and braking systems in motorsports.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Demonstrate their knowledge on the fundamentals of race car design and development.*	*2*	*75*	*75*	*H*	*H*	*H*	*M*	*L*	*M*	*L*	*H*	*H*	*H*	*L*	*H*	*H*	*M*	*H*
CLO-2 :	*Identify the aerodynamic requirements of a race car and characteristics of various aerodynamic devices.*	*2*	*80*	*80*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*H*	*M*	*L*	*L*	*H*	*H*	*M*	*H*
CLO-3 :	*Interpret the effects of various dynamic conditions on a race car chassis.*	*2*	*80*	*80*	*H*	*H*	*H*	*M*	*L*	*M*	*L*	*H*	*M*	*L*	*L*	*H*	*H*	*M*	*H*
CLO-4 :	*Compare and classify the different types of suspension systems used in racing.*	*2*	*75*	*75*	*M*	*M*	*M*	*M*	*L*	*M*	*L*	*H*	*M*	*L*	*L*	*H*	*H*	*M*	*H*
CLO-5 :	*Identify the appropriate drives and braking systems for the required racing applications.*	*2*	*75*	*75*	*M*	*M*	*M*	*M*	*L*	*M*	*L*	*H*	*M*	*L*	*L*	*M*	*H*	*M*	*H*

Duration (hour)		Race Car Design and Development	Race Car Aerodynamics	Race Car Chassis	Race Car Suspension System	Race Car Drives And Braking Systems
		9	9	9	9	9
S-1	SLO-1	*Problems Imposed By Racing*	*Aerodynamic Force And Moment, Race Car Drag Components*	*Conditions For Traversing A 90° Corner*	*Front Suspension- General Design Issues, Camber Effects.*	*Merits Of Front and Rear wheel drive in racing.*
	SLO-2	*Racing Objective*	*Drag Estimation and Drag Improvement*	*Principle Chassis Tuning Items*	*McPherson Struts, SLA Suspension.*	*Four-Wheel Drive In Racing.*
S-2	SLO-1	*"g-g" Diagram*	*Ground Effects in a race car*	*Effects Of High Speed Braking*	*SLA suspension geometry, Instant Axis Concept.*	*Differentials Used In Racing- Open Differentials, Locked (Spool) differentials.*
	SLO-2	*Road car vs race car "g-g" Diagram.*	*Ground Plane Simulation In Race Car Applications.*	*Effects Of High Speed Cornering*	*SLA Rear Suspension, Beam Axle Rear Suspensions, Decoupled Rear Axle Suspension*	*Limited Slip Differential*
S-3	SLO-1	*Constraints And Specifications – Performance and Handling*	*Spoilers, Dams, Wings*	*Effects of Combined Braking Cornering*	*F1 car suspension: Double wishbone and outboard spring*	*Traction Control And Other Electronic Improvements In Racing.*
	SLO-2	*Constraints And Specifications –Structure, weight distribution.*	*Effectiveness Of Wings In Steady State Cornering.*	*Steady State Cornering*	*Top rocker and inboard spring, pull-rod and inboard spring*	*Traction Control And Other Electronic Improvements In Racing.*
S-4	SLO-1	*Driver Accommodation And Safety.*	*High Lift Devices- Flaps And Slats.*	*Acceleration Out Of A Corner*	*Push rod and vertical coil spring, push rod and horizontal coil spring and damper*	*Mechanical Components In Braking System.*
	SLO-2	*Tire and adjustable features.*	*Flow Control Devices- Dams, Fences, Vanes, Skirts, Spoilers.*	*Straight Line Acceleration*	*Push rod and Vertical torsion bar with horizontal damper*	*Mechanical Components In Braking System.*
S-5	SLO-1	*Preliminary Design And Analysis.*	*Vortex Creating Devices- Ledges, Edge, Cusps, Lips.*	*Throttle Behaviour*	*Suspension Springs- Torsion Springs, Coil Springs*	*Limitations And Considerations Of Braking In Racing.*
	SLO-2	*Driver-Vehicle Relationship*	*Pressure Change Creation Devices- Perforations, Vents, Bleeds, Scoops, Seals.*	*Steering Wheel Force And Kick Back*	*Progressive Rate Coil Springs*	*Limitations And Considerations Of Braking In Racing.*

Duration (hour)		Race Car Design and Development	Race Car Aerodynamics	Race Car Chassis	Race Car Suspension System	Race Car Drives And Braking Systems
		9	9	9	9	9
S-6	SLO-1	*Desirable Vehicle Characteristics.*	*Air-Foil Devices- Slats, Flaps, End Plates, Cuffs, Fillets, Trips.*	*Moving CG Position, Ballasts.*	*Installation Consideration*	*Brake Boost in racing*
	SLO-2	*Fundamentals Of Testing*	*Active Flow Control Devices- Internal Airflow, RAM Air Ducted Radiator, Air Entrance Scoop*	*Effect of engine weight reduction on longitudinal CG position.*	*Damping In Racing, Ride/Handling Compromise*	*Effects Of "g" Force On Brake Fluids*
S-7	SLO-1	*Track Test Program Planning*	*Full size wind tunnel testing*	*Roll Center Position Changing Anti-Pitch Geometry*	*Steering Activity, Transient Maneuvering*	*Brake Hydraulics*
	SLO-2	*Test Methodology*	*Full size wind tunnel testing*	*Chassis Steering Axis Geometry, Changing Camber*	*Bump Damping And Rebound Damping*	*Brake Ventilation*
S-8	SLO-1	*General Notes On Development*	*Case study: Chaparral wings*	*Chassis Ride Roll Characteristics*	*Racing damper schematic*	*Brake Distribution*
	SLO-2	*Circular Skid Pad Testing.*	*Case study: Performance benefits from the Chaparral wings.*	*Chassis Track Width , Chassis Ride Spring Rate, Tires And Rims*	*Case study: Penske four-way adjustable damper.*	*ABS In Racing*
S-9	SLO-1	*Case study- 1955 Mercedes W196 Grand Prix car.*	*Case study: Formula Benetton's pressurized, half-scale wind tunnel.*	*Adjusting Roll Stiffness*	*Lateral restraints- Pan hard bar, Watts's linkage.*	*Carbon-Carbon discs.*
	SLO-2	*Case study- 1998 Ferrari F300 Grand Prix car.*	*Case study: Moving ground plane Benetton's wind tunnel.*	*Roll Stiffness Distribution*	*Cam and follower in track, A-arms.*	*Case study: Ferrari F300 two-pedal arrangement for braking.*

Learning Resources		
	1. *William F.Milliken and Douglas L.Milliken, "Race car vehicle dynamics", 11th edition, SAE, 1995.*	3. *Thomas D. Gillespie, "Fundamental of Vehicle Dynamics, Society of Automotive Engineers", USA 11th edition , 2006*
	2. *Peter Wright, "Formula 1Technology", 2001.*	4. *Wolf-Heinrich Hucho, "Aerodynamics of road vehicles", 4th edition, 2000.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Alisha Abdullaha, RACING Academy for women, AlishaAbdullaha24@gmail.com	*1.Dr.R.Jagadeeshwaran, BIT, profresearch@bitsathy.ac.in*	*1. Dr. K.Kamalakkannan SRMIST, kamalakk1@srmist.edu.in*
2. Mr.N.Yogesh, RNTBCI, Yogesh.nagendiran@rntbci.com	*2. Mr.R.Ragavendran HITS, Motorsports@hindustanuniv.ac.in*	*2. Mr.M.Deepak,SRMIST, deepakm@srmist.edu.in*

Course Code	18AUE356T	Course Name	AUTOMOTIVE NVH	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 fundamentals of noise and vibration theory*
CLR-2 :	*Explain fundamental principles of sound quality and vibration modal analysis*
CLR-3 :	*Equip themselves familiar with basics of vibration and their mathematic models*
CLR-4 :	*Understand measuring instrumentations, techniques and metrics used for automotive NVH*
CLR-5 :	*Understands the various automotive noise sources and their control techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Identify the basics of vibration and formulate the equations for various types of vibrations*	*3*	*95*	*80*
CLO-2 :	*Design various vibration control techniques*	*3*	*95*	*80*
CLO-3 :	*Interpret fundamental of noise and its transmission*	*2*	*85*	*80*
CLO-4 :	*Compare and classify different vibration measurement test*	*3*	*90*	*85*
CLO-5 :	*Explain the causes of automotive noise and its control methods*	*3*	*95*	*90*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
H	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*H*	*L*	*L*
H	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*H*	*H*	*L*
H	*M*	*H*	*M*	*M*	*L*	*H*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*M*
H	*M*	*H*	*H*	*M*	*L*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*M*
H	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*L*	*L*	*L*	*M*	*H*	*M*	*M*

Duration (hour)		Basics of Vibration Analysis	Vibration Control Techniques	Noise Fundamentals	NVH Measurements	Automotive Noise Sources and Control Techniques
		9	9	9	9	9
S-1	SLO-1	*Basic concepts*	*Transmissibility Ratio*	*Fundamental of acoustics*	*Vibration and Noise Standards*	*Engine noise- causes*
	SLO-2	*Formulating the equations of motion*	*Transmissibility ratio and its different cases*	*General sound propagation*	*Pass/Drive by noise-test site*	*Methods for control of engine noise-control measures-*
S-2	SLO-1	*Free undamped vibration*	*Vibration isolation*	*Structure borne sound& air borne sound*	*Pass/Drive by noise meteorological condition*	*Mufflers*
	SLO-2	*Free undamped vibration*	*Vibration isolation*	*Structure borne sound& air borne sound*	*Pass/Drive by noise meteorological condition*	*Mufflers*
S-3	SLO-1	*Free damped vibration*	*Tuned viscous dampers*	*Plane wave propagation - wave equation*	*Pass/Drive by noise-constant speed test- wide open throttle test*	*Transmission Noise- control methods*
	SLO-2	*Free damped vibration*	*Tuned viscous dampers*	*Specific acoustic impedance, acoustic intensity*	*Pass/Drive by noise-constant speed test- wide open throttle test*	*Transmission Noise- control methods*
S-4	SLO-1	*Logarithmic decrement*	*Tuned viscous dampers*	*Spherical wave propagation*	*Interior Noise test- standards – test track condition*	*Intake and exhaust noise – attenuation of intake and exhaust noise*
	SLO-2	*Graphical analysis of Logarithmic decrement*	*Tuned viscous dampers*	*Acoustic near and far fields*	*Interior Noise test- standards– vehicle operating condition*	*Intake and exhaust noise – attenuation of intake and exhaust noise*
S-5	SLO-1	*Forced Vibration*	*Untuned viscous dampers*	*The decibel scale, Summation of pure tones*	*Interior Noise test- standards steady speed – Full throttle test –stationery test*	*Control methods dissipative silencers – reactive silencers - resonators*
	SLO-2	*Magnification Factor*	*Untuned viscous dampers*	*Relationship among sound power, sound intensity and sound pressure level*	*Interior Noise test- standards-microphone positions*	*Aerodynamic Noise, its sources and control methods*
S-6	SLO-1	*Magnification Factor Different Cases*	*Untuned viscous dampers*	*Relationship among sound power, sound intensity and sound pressure level*	*Stationery vehicle test- standards*	*Tyre Noise, Brake noise and their control methods*
	SLO-2	*Magnification Factor Different Cases*	*Untuned viscous dampers*	*Relationship among sound power, sound intensity and sound pressure level*	*Stationery vehicle test- test site*	*Tyre Noise, Brake noise and their control methods*

Duration (hour)		Basics of Vibration Analysis	Vibration Control Techniques	Noise Fundamentals	NVH Measurements	Automotive Noise Sources and Control Techniques
		9	9	9	9	9
S-7	SLO-1	*Torsional system characteristics and single disc*	*Damping treatments and its significance*	*Decibel addition, subtraction and averaging matrix from element stiffness*	*Stationery vehicle test- preparation of the vehicle*	*Noise control strategy, noise control at source*
	SLO-2	*Torsional system characteristics of two disc*	*Damping treatments and its significance*	*Decibel addition, subtraction and averaging matrix from element stiffness*	*Stationery vehicle test-vehicle operating condition*	*Noise control along the transmission path*
S-8	SLO-1	*Two degree of freedom systems under harmonic force, modal analysis.*	*Free layer damping*	*Anatomy of Human Ear,*	*NVH measurement tools and techniques*	*Barriers, enclosures*
	SLO-2	*Modal analysis.*	*Free layer damping*	*Anatomy of Human Ear,*	*NVH measurement tools and techniques- vibration and noise measurement transducers*	*Resonators*
S-9	SLO-1	*Coordinate coupling*	*Constrained Layer damping*	*Mechanism of hearing*	*Advanced acquisition techniques*	*Industrial noise control measures-*
	SLO-2	*Coordinate coupling*	*Constrained Layer damping*	*Mechanism of hearing*	*Advanced acquisition techniques*	*Green belt development*

Learning Resources	1. *Singiresu S. Rao , "Mechanical Vibrations" 5th Edition, Pearson, September , 2010* 2. *Ambekar, A. G., "Mechanical Vibrations and Noise Engineering", Prentice Hall of India, New Delhi, 2006* 3. *Munjal , "Acoustics of Ducts and Mufflers" Wiley publications, 2010* 4. *Beranek, L. L. and Ver, I, L., "Noise and Vibration Control Engineering –Principles and Application", John Wiley & Sons, Inc, 1992* 5. *Beranek, Leo Leroy ,"Acoustic measurements" 10th Edition 2007* 6. *Manasi P. Joshi, "Noise &Vibration Measurement Techniques in Automotive NVH " 2012* 7. *Malcolm J. Crocker , "Handbook Of Noise And Vibration Control" John Wiley & Sons, Inc 2007*

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. M. Shivakumar, Mahendra and Mahendra, sivakumar.k2309@gmail.com	*1. Dr.V.Gnanamoorthy, UCEV,Anna University, cvgnana@gmail.com*	*1. Dr. K. Kamalakannan, SRMIST,kamalakk1@srmist.edu.in*
2. Mr. S. Prabhakar, Hyundai Motors, prabhakarjeevamit@gmail.com	*2. Mr. R. Selvakumar, Hindustan Institute of technology, rselvak@hindustanuniv.ac.in*	*2. Mr. T. Kaviyarasu, SRMIST, kaviyart@srmist.edu.in*

Course Code	18AUE451T	Course Name	ADVANCED VEHICLE TECHNOLOGY	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 electric and hybrid vehicle operation and architectures*
CLR-2 :	*Analyse the suspension system used in automobiles*
CLR-3 :	*Identify suitable methods to reduce the noise emission and categorize the emission norms*
CLR-4 :	*Apply the function, construction and operation of various sensors and actuators*
CLR-5 :	*Understand the basics of control system used in automobiles*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand various trends in automotive power plants*	*2*	*95*	*92*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*L*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-2 :	*Gain knowledge about various modern suspension and braking systems*	*2*	*96*	*90*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*L*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-3 :	*Understand various emissions and noise pollution control techniques*	*2*	*95*	*90*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*L*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-4 :	*Understand the fundamentals of modern sensors, actuators, ignition and injection systems*	*2*	*93*	*89*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*L*	*H*	*L*	*L*	*L*	*H*	*M*	*H*
CLO-5 :	*Gain knowledge about automated tracks for safe and fast travel*	*2*	*95*	*90*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*L*	*H*	*L*	*L*	*L*	*H*	*M*	*H*

Duration (hour)		Trends in Automotive Power Plants	Suspension and Brakes	Emission And Noise Pollution Control	Vehicle Operation and Control	Vehicle Automated Tracks
		9	9	9	9	9
S-1	SLO-1	*Introduction to power plant*	*Introduction to suspension systems*	*Sources of Pollution. Various emissions from Automobiles*	*Fundamentals of Automotive Electronics*	*Introduction automated tracks*
	SLO-2					
S-2	SLO-1	*Lean Burn Engines*	*Interconnected Air And Liquid Suspensions*	*Formation — Effects of pollutants on environment human beings.*	*Introduction to sensors, actuators, Processors*	*Road network*
	SLO-2	*Working principle of lean Burn engines*	*Hydro Elastic Suspension System*	*Emission control techniques*	*Introduction to sensors, actuators, Processors*	*Road network Preparation*
S-3	SLO-1	*Stratified Charged*	*Hydro Gas Suspension*	*Emission standards*	*Sensors : Position, speed,*	*Maintenance Of Proper Road Network*
	SLO-2	*Stratified Charged*	*Closed Loop Suspension*	*Engine Emissions, Types Of Catalytic Conversion-*	*Acceleration/Vibrational , Force/Torque, Flow meters,*	*Traffic survey*
S-4	SLO-1	*Needs, advantages and dis advantages of Hydrogen Engines*	*Introduction to brakes*	*Charcoal Canister*	*Automotive Actuators*	*proposed road priority index*
	SLO-2	*Hydrogen Engines*	*Modern Rear Wheel Brake*	*CI engine emission and its control*	*Electromechanical actuators*	*Working principle*
S-5	SLO-1	*Need for Hybrid Vehicles*	*Self-Energizing Disc Brake*	*Formation — Smokes, NOx, soot, sulphur particulate*	*Fluid-mechanical actuators*	*Automated highway system*
	SLO-2	*Hybrid Vehicles working principle*	*Indirect Floating Caliper Disc Brake Brake Limiting Device,*	*Control Techniques-Fumigation, EGR, HCCI, Particulate Traps, SCR*	*Computer Control for pollution, noise and for fuel economy*	*Advantages and disadvantages*
S-6	SLO-1	*Concept of electric vehicles*	*Power–Assisted Braking System*	*Sources of Noise*	*Basics of networks*	*National Highway Network With Automated Roads And Vehicles*
	SLO-2	*Electric Propulsion With Cables*	*Power–Assisted Braking System*	*Engine Noise, Transmission Noise, vehicle*	*Examples of networked Vehicles - Bus system*	*National Highway Network With Automated Roads And Vehicles*
S-7	SLO-1	*Fuel cell introduction*	*Constructional Details Anti-Skid System*	*Structural Noise, aerodynamics noise*	*Introduction to Control area network in vehicle*	*Satellite Control Of Vehicle Operation For Safe And Fast Travel*

Duration (hour)		Trends in Automotive Power Plants	Suspension and Brakes	Emission And Noise Pollution Control	Vehicle Operation and Control	Vehicle Automated Tracks
		9	9	9	9	9
	SLO-2	*Fuel cell Vehicles*	*Anti-Skid System*	*Exhaust Noise. Noise reduction in Automobiles*	*Control area network in vehicle*	
S-8	SLO-1	Introduction about the Magnetic Track Vehicles	Regenerative Braking	Noise Control Techniques.	Electronic Fuel Injection	Intelligent transportation systems
	SLO-2		Working principle of Regenerative Braking	Silencer Design.		
S-9	SLO-1	Magnetic Track Vehicles.	Constructional Details. Active suspension	Noise Control Techniques.	Electronic Ignition system	Transducers and Operation Of The Vehicle Like Optimum Speed And Direction
	SLO-2					

Learning Resources	
1. *T. K. Garrett "The Motor Vechicle"., 13th edition 2009.*	4. *Heinz Heisler, "Advanced vehicle technology"., elsevier Store.2002*
2. *Dr. N.K. Giri, "Automobile Mechanic", Khanna Publishers, 2006*	5. *Crouse/Anglin "Automotive Mechanics" Career Education; 10th edition January 13, 1993*
3. *Beranek. L.L. "Noise Reduction"., McGraw-Hill Book Co., Inc, Newyork, 1993*	6. *"Bosch Hand Book"., 3rd Edition, SAE,1993*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. MyilavanPalanivel, WABCO indialimited ,myliavan@gmail.com	*1. Dr.P D Jeyakumar, Cresent University, pdjeyakumar@cresent.education.*	*1.. Dr K. Kamalakkannan SRMIST Kamalakk1@srmist.edu.in*
2. Mr.R Siva, GMMCO, rsiva@gmmco.com.	*2. Dr.K Prabu, VIT, Prabu.k@vit.ac.in*	*2.Mr.S.Devanand,SRMIST, devanans@srmist.edu.in*

Course Code	18AUE452T	Course Name	AUTOMOTIVE SAFETY AND ERGONOMICS	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 :	*Impart knowledge on basics of vehicle construction details and its effects.*
CLR-2 :	*Know the various safety concepts used in passenger cars.*
CLR-3 :	*Gain knowledge about various safety systems and its equipment.*
CLR-4 :	*Understand the concepts of vehicle ergonomics.*
CLR-5 :	*Interpret the various automotive comfort features.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the fundamentals of design and construction of vehicle body.*	*1*	*80*	*75*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*H*	*L*	*L*
CLO-2 :	*Classify the various safety parameters such as interior and exterior safety concepts.*	*2*	*75*	*70*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-3 :	*Understand the concepts of active and passive safety systems for real time application.*	*2*	*80*	*77*	*H*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-4 :	*Implementing the vehicle ergonomics for enhancing the comfort level.*	*3*	*75*	*70*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*M*
CLO-5 :	*Describe the different types of comfort and convenience systems.*	*2*	*85*	*80*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*

Duration (hour)		Design and Construction of Vehicle Body	Interior and Exterior Safety Concepts	Active and Passive Safety systems	Vehicle Ergonomics	Comfort and Convenience Systems
		09	09	09	09	09
S-1	SLO-1	*Introduction to design and construction of vehicle body*	*Safety concepts- Introduction*	*Introduction to safety systems*	*Introduction to human body*	*Comfort and Convenience Systems- Introduction*
	SLO-2	*Design of the body for Safety. Energy equations, Engine location*	*Active safety, Driving safety, Conditional safety*	*Seat belt, Automatic seat belt fastening system*	*Anthropometrics and its application to vehicle ergonomics*	*Cabin comfort - In-Car air conditioning – overall energy efficiency*
S-2	SLO-1	*Effects of deceleration inside passenger compartment*	*Perceptibility safety*	*Collapsible steering column*	*Cockpit design*	*Air Management, Central and unitary systems, Air flow circuits*
	SLO-2		*Operating safety*	*Tiltable steering wheel*		*Air Cleaning, Ventilation, Air space diffusion*
S-3	SLO-1	*Deceleration on impact with stationary and movable obstacle*	*Passive safety*	*Air bags*	*Driver comfort – seating, visibility*	*Compact heat exchanger design, Controls and Instrumentation*
	SLO-2		*Exterior Safety*	*Electronic systems for activating air bags*		*Compact heat exchanger design, controls and Instrumentation*
S-4	SLO-1	*Concept of crumble zone and safety sandwich construction*	*Interior Safety Systems*	*Frontal design for safety*	*Driver comfort – Seat pan, Back rest, Steering wheel, Head rest and mirrors*	*Steering and mirror adjustment*
	SLO-2			*Collision warning system*		*Central locking system*
S-5	SLO-1	*Active and passive safety*	*Deformation behaviour of vehicle body*	*Causes of rear end collision, frontal object detection*	*Man-Machine system*	*Garage Door Opening System, Tire Pressure Control System, Rain sensor System*
	SLO-2			*Rear vehicle object detection system*	*Psychological factors – stress, attention*	*Environment information System, Automotive lamps, Types, Design, Construction, performance*
S-6	SLO-1	*Characteristics of vehicle structures*	*Speed and acceleration characteristics of passenger compartment on impact*	*Object detection system with braking system interactions*	*Passenger comfort - Ingress and Egress*	*Light signalling devices- stop lamp*
	SLO-2				*Spaciousness*	*Rear position lamp, Direction indicator*
S-7	SLO-1		*Pedestrian safety*	*Anti-lock braking system*	*Ventilation, Temperature control*	*Reverse lamp, Reflex reflector*

Duration (hour)		Design and Construction of Vehicle Body	Interior and Exterior Safety Concepts	Active and Passive Safety systems	Vehicle Ergonomics	Comfort and Convenience Systems
		09	09	09	09	09
	SLO-2	*Optimization of vehicle structures for crash worthiness*	*Human impact tolerance- Determination Of injury thresholds*		*Dust and fume prevention*	*Position lamp, Gas discharge lamp, LED*
S-8	SLO-1	*Types of crash / Roll over tests*	*Severity index, Study of comparative tolerance*	*ESP And EBD Systems*	*Interior features and conveniences*	*Adoptive Front Lighting System (AFLS)*
	SLO-2	*Regulatory requirements for crash testing*		*Adaptive Cruise Control (ACC)*		*Daylight Running Lamps (DRL)*
S-9	SLO-1	*Instrumentation, High speed photography*	*Study of crash dummies*	*Navigation systems, traffic telematics*	*Placement of vehicle controls*	*Role of MCU in security and safety features*
	SLO-2	Image analysis.		*Infrared night vision system*	*Use of Modern technology for the same*	

Learning Resources	
1.	*Prasad, Priya and Belwafa Jamel, "Vehicles Crashworthiness and Occupant Protection", American Iron and Steel Institute, USA.*
2.	*JullianHappian-Smith "An Introduction to Modern Vehicle Design" SAE, 2002*
3.	*Bosch - "Automotive Handbook" - 10th edition - SAE publication - 2018.*
4.	*"Recent development in Automotive Safety Technology", SAE International Publication. Editor: Daniel J Helt, 2013.*
5.	*Keitz H.A.E. "Light Calculations and Measurements", Macmillan 1971.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Dhanraj domalaXitadel, Dhanraj.domala@xitadel.com	*1 .Dr.V. Uma Maheshwar, Osmania University, mahesh.v@uceou.edu,*	*1. Dr. K.Kamalakkannan SRMIST kamalakk1@srmist.edu.in*
2.Mr.GopalDhanasekar, ATS Gopal.dhanasekar@ats_india.com	*2. .Mr.A.Muthuvel, Sairam Engineering College, Muthuvel.mech@sairamce.edu.in*	*2. Dr. T.Praveenkumar, SRMIST praveent@srmist.edu.in*

Course Code	18AUE453T	Course Name	VEHICLE MAINTENANCE	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 :	*Learn how to maintain the various systems and components in an automobile*
CLR-2 :	*Effectively troubleshoot common problems in an automobile*
CLR-3 :	*Prevent premature failure of components and systems by audio-visual inspection*
CLR-4 :	*Ensure the safety of occupants by preventive maintenance*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand vehicle operation and maintenance principles*	*3*	*90*	*90*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*L*	*H*	*L*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Understand and perform scheduled services*	*3*	*90*	*90*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-3 :	*Handle situations where the vehicle is likely to fail*	*3*	*90*	*90*	*H*	*H*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*L*	*M*
CLO-4 :	*Understand maintenance procedures like repairing, overhauling etc.,*	*3*	*90*	*90*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*L*	*H*	*L*	*H*	*H*	*H*	*H*	*H*

Duration (hour)		Maintenance of Workshop Records and Schedules	Powertrain Maintenance	Vehicle Chassis and Body Maintenance	Electrical System Maintenance	Maintenance of Auxiliary Systems
		09	09	09	09	09
S-1	SLO-1	*Importance Of Maintenance, Scheduled And Unscheduled Maintenance*	*Dismantling Of Engine Components And Cleaning*	*Maintenance And Servicing Of Front Axle*	*Testing Methods For Checking Electrical Components*	*Servicing Of Fuel System Of Different Types Of Vehicles*
	SLO-2					
S-2	SLO-1	*Requirements Of Maintenance*	*Cleaning Methods*	*Maintenance And Servicing of Rear Axle*	*Checking of Battery*	*Maintenance Of Fuel System Of Different Types Of Vehicles*
	SLO-2	*Preparation Of Check Lists*	*Visual And Dimensional Inspections*	*Maintenance And Servicing of Suspension Systems*	*Checking of Starter Motor*	*Calibration And Tuning Of Engine For Optimum Fuel Supply*
S-3	SLO-1	*Vehicle Down Time*	*Minor And Major Reconditioning Of Various Components*	*Maintenance And Servicing of Braking Systems*	*Checking of Charging System*	*Maintenance of Cooling System*
	SLO-2	*Vehicle Inspection, Inspection Schedule*	*Reconditioning Methods*	*Overhauling of Steering Systems*	*Checking of, DC Generator*	*Water Pump, Radiator*
S-4	SLO-1	*Maintenance Of Records, Reports*	*Engine Assembly*	*Maintenance of Steering Systems*	*Checking of Alternator*	*Thermostat*
	SLO-2	*Log Books, Trip Sheets And Other Forms*	*Special Tools Used For Maintenance And Overhauling*	*Wheel Alignment*	*Checking of Ignition Systems*	*Anticorrosion And Antifreeze Additives*
S-5	SLO-1	*Safety Precautions In Maintenance*	*Engine Tune Up*	*Computerized Alignment*	*Checking of Lighting Systems*	*Maintenance of Lubrication System*
	SLO-2	*Fleet Maintenance Requirement*	*Layout of transmission system*	*Wheel Balancing*	*Fault Diagnosis Of Modern Electronic Controls*	*Different grades of oil*
S-6	SLO-1	*Work Shop Layout*	*Servicing And Maintenance Of Automobile Clutch*	*Troubleshooting Checklist For Front Axle*	*Maintenance Of Modern Electronic Controls*	*lubricant oil additives*
	SLO-2	*Tools And Equipment*	*Servicing And Maintenance Of Gear Box*	*Troubleshooting Checklist For Rear Axle*	*Checking Of Dash Board Instruments*	*Lubricating Oil Changing*
S-7	SLO-1	*Spare Parts And Lubricants Stocking*	*Servicing And Maintenance Of Propeller Shaft*	*Troubleshooting Checklist For Suspension Systems*	*Servicing Of Dash Board Instruments*	*Greasing Of Parts*
	SLO-2	*Manpower, Training*	*Servicing And Maintenance Of Differential System*	*Troubleshooting Checklist For Steering Systems*	*Trouble Shooting On Engine Management System*	*Minor And Major Repairs Of Body Parts*

Duration (hour)		Maintenance of Workshop Records and Schedules	Powertrain Maintenance	Vehicle Chassis and Body Maintenance	Electrical System Maintenance	Maintenance of Auxiliary Systems
		09	09	09	09	09
S-8	SLO-1	*Workshop Management*	*Trouble Shooting Checklist For Engine*	*Body Panel Tools For Repairing*	*Multi-Scanner*	*Maintenance Of Door Locking Mechanism*
	SLO-2	*Warranty*	*Trouble Shooting Checklist For Clutch*	*Body Panel Tools for Tinkering And Painting*	*On Board Diagnosis Using Multi-Scanner*	*Maintenance Of Window Glass Actuating System*
S-9	SLO-1	*Replacement Policy*	*Trouble Shooting Checklist Gear Box*	*Case studies*	*Case-Studies*	*Case-Studies*
	SLO-2		*Case-Studies*			

Learning Resources	*1. John Doke, "Fleet Management", McGraw Hill Co. 1984* *2. James D Halderman, "Advanced Engine Performance Diagnosis", PHI, 1998*	*3. Tim Gilles, "Automotive service", 5th edition, Delmar CENGAGE Learning, 2009.* *4. Service manuals.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
	Analyze										
Level 3	Evaluate	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Ram Prasanth A,Caterpillar India Pvt Ltd, anjaneyulu_ram_p@cat.com	*1. Mr. NanthaKumar P, Amirta School of Engineering, p_nanthakumar@cb.amrita.edu*	*1. Dr. K.Kamalakkannan, SRMIST kamalakk1@srmist.edu.in*
2.Mr.Jayaraman R, BLG Logistics, jayaraman.r@blgparekh.com	*2. Mr. Sakthivel.R, Sri Venkateswara College of Engineering, sakthivel@svce.ac.in*	*2. Mr.. Boopathi D, SRMIST boopathd@srmist.edu.in*

Course Code	18AUE454T	Course Name	VEHICLE BODY ENGINEERING AND AERODYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AUC302J*	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 different types of vehicle body structures and their details*
CLR-2 :	*Know the details of bus bodies, classification and its regulations*
CLR-3 :	*Impart knowledge on the concept of car aerodynamics and testing of scale models*
CLR-4 :	*Classify different types of commercial vehicles and its types*
CLR-5 :	*Understand the various concepts of commercial vehicle aerodynamics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the fundamentals of various automotive body construction details*	*1*	*80*	*75*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*M*	*H*	*L*	*M*
CLO-2 :	*Classify the various types of bus body construction and able to identify the body layout.*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-3 :	*Understand the concepts of car aerodynamics in body engineering for better style and low drag.*	*1*	*80*	*78*	*H*	*H*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-4 :	*Select a suitable body optimization technique to minimize drag and able to describe the wind tunnel testing procedure*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-5 :	*Describe the different types of commercial vehicles and its design*	*2*	*85*	*80*	*H*	*L*	*H*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-6 :	*Apply the concept of commercial vehicle aerodynamics for reducing the drag.*	*2*	*75*	*72*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*H*	*M*	*L*

Duration (hour)		Car Body Details	Bus Body Details	Car Aerodynamics	Commercial Vehicle Details	Commercial Vehicle Aerodynamics
		9	9	9	9	9
S-1	SLO-1	*History - Evolution of vehicle body, Importance of vehicle body*	*Introduction to bus bodies*	*Car Aerodynamics - Introduction*	*Commercial vehicles - Introduction*	*Commercial vehicle aerodynamics - Introduction*
	SLO-2	*Car Body Terminologies & types of car bodies*	*Bus body panels & terminologies*	*Importance of Aerodynamics*	*Classification of Commercial vehicle bodies*	*Importance of Commercial vehicle Aerodynamics*
S-2	SLO-1	*Visibility - Forward visibility*	*Classification of bus body*	*Types of Aerodynamic drag*	*LCV – Light commercial vehicles and its types – Pickups and delivery vans*	*Effects of rounding sharp front body edges*
	SLO-2	*Forward vision measurement and Regulations*	*Based on distance travelled by the vehicle*			
S-3	SLO-1	*Driver's Visibility, All round visibility of the vehicle – sensors and its functions*	*Based on capacity of the vehicle*	*Various Aerodynamic forces and moments*	*HCV - Heavy commercial vehicles and its types*	*Effects of various cabs on trailer body*
	SLO-2	*Methods of improving visibility*	*Based on shape and style of the vehicle*			
S-4	SLO-1	*Safety - factors influencing safety in traffic*	*Based on types of metal section used*	*Effect of Aerodynamic forces and moments*	*Dimensions of commercial vehicle driver's seat in relation to various controls*	*Fore body pressure distribution*
	SLO-2	*Classification - Active & Passive safety*	*Bus body regulations*			
S-5	SLO-1	*Active safety - Driving, Conditional, Perceptibility & Operational safety*	*Sequence of bus building operation*	*Various body optimization techniques for minimum drag*	*Constructional details of Tanker body*	*Effect of Cab to trailer body roof height*
	SLO-2	*Passive safety - Interior & Exterior safety*				
S-6	SLO-1	*Safety aspects in design - Bumper end, front end*	*Construction of conventional type of bus body*	*Wind tunnel technology - Principle & Construction details*	*Construction of Tipper body*	*Effects of a cab to trailer body gab seals*
	SLO-2	*Safety aspects in design - Rear end and importance of larger distance*			*Various tipping methods*	
S-7	SLO-1	*Passive Safety devices - Air bag*	*Construction of Integral type of bus body*	*Types of wind tunnels*	*Various Tipping mechanisms*	*Commercial vehicle drag reducing devices*
	SLO-2	*Telescopic/Collapsible Steering column*			*Flat platform and drop side body construction*	*Cab roof deflectors & Corner Vanes*
S-8	SLO-1	*Active Safety devices*			*Segmental design of driver's cab*	*Vortex generators and Diffusers*

Duration (hour)		Car Body Details	Bus Body Details	Car Aerodynamics	Commercial Vehicle Details	Commercial Vehicle Aerodynamics
		9	9	9	9	9
	SLO-2	*Modern Painting process of a passenger car body*	*Comparison of test results of integral and conventional bus.*	*Flow visualization techniques – Smoke method, Tuft method, Oil coating method*		*Tractor and Trailer Skirting*
S-9	SLO-1	*Selection of paint and painting process*	*Frame Construction*	*Testing with wind tunnel balance (scale models)*	*Compactness of Driver's cab*	*Effect of Trailer load position on vehicle's drag resistance*
	SLO-2	*Corrosion and Anti corrosion methods*	Double Skin construction			

Learning Resources	*1. Pawloski J, " Vehicle Body Engineering" - Business Books Ltd.,* *2. Wolf-Heinrich Hucho, "Aerodynamics of road vehicles", 4th edition, 2000.*	*3. John Fenton, "Vehicle Body layout and analysis", Mechanical Engineering Publication Ltd., 1984* *4. Heinz Heisler, "Advanced Vehicle Technology", 2nd edition, Butterworth – Heinemann, 2002.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
	Analyze										
Level 3	Evaluate	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Franklin Darlie, HAL, Frank_darlie@rediff.com	*1.Dr.C.Prasad HITS, cprasad@hindustanuniv.ac.in*	*1.. Dr K. Kamalakkannan SRMIST, kamalakk1@srmist.edu.in*
2.Mr.V.Raja Raman Altair, rajarav@asiapac.altair.com	*2.Mr.A.Muthuvel, Sairam College of Engioneering, muthuvel.mech@sairamce.edu.in*	*2. Mr.S.Kiran ,SRMIST, kirans@srmist.edu.in*

Course Code	18AUE455T	Course Name	MACHINE LEARNING APPROACH FOR AUTOMOTIVE APPLICATIONS	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 Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	List and recognize the various machine techniques and condition monitoring techniques.	1	90	85	H	M	M	M	L	L	L	L	M	M	L	M	H	M	M
CLO-2 :	Identify and Estimate Parameters of signals using different sensors.	2	90	85	H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
CLO-3 :	Identify and use various signal processing techniques.	2	85	80	H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
CLO-4 :	Relate and use the various classification and regression models.	2	85	80	H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
CLO-5 :	Investigationof condition monitoring for automotive application.	3	85	80	H	H	H	H	M	H	H	M	M	M	M	H	H	H	H

Duration (hour)		Introduction to Condition Monitoring	Instrumentation	Signal processing	Pattern Recognition	Application and case studies of condition monitoring
		09	09	09	09	09
S-1	SLO-1	Introduction to Machine Learning	Types of Sensors in Condition Monitoring and its Application	Basic Signal and Systems Concepts	Feature Extraction Methods	Application and Case Studies of Bearings
	SLO-2	Introduction to Condition Monitoring	Types of Sensors in Condition Monitoring and its Application	Basic Signal and Systems Concepts	Feature Selection Methods	Application and Case Studies of Bearings
S-2	SLO-1	Types of Machine Learning Techniques	Different Types of Vibration Sensors	Time Domain Analysis	Feature Reduction using PCA - Discriminant Functions	Case Study of Gearbox
	SLO-2	Supervised, Unsupervised And Reinforcement Learning	Working Principle of Piezoelectric Type Transducer	Time Domain Analysis	Feature Reduction using PCA - Decision Boundaries	Case Study of Gearbox
S-3	SLO-1	Machinery Failures	Different Types of Sound Sensors	Frequency Domain Analysis	Feature Reduction using Decision Tree	Case Study of Engines
	SLO-2	Basic Maintenance Strategies	Working Principle of Free Field Array Microphone	Frequency Domain Analysis	Feature Reduction using Decision Tree	Case Study of Engines
S-4	SLO-1	Factors Influencing Maintenance Strategies	Basic Principle of Acoustic Emission (AE) Signals	Time-Frequency Analysis	Classification using Maximum Likelihood and Nearest Neighbour	Structural Health Monitoring
	SLO-2	Factors Influencing Maintenance Strategies	Working Principle of AE Sensors	Time-Frequency Analysis	Bayesian Theory	Structural Health Monitoring
S-5	SLO-1	Machine Condition Monitoring	Types of Temperature Sensors and its Working Principle	Wavelets Analysis	Neural Networks	Machine Tool Condition Monitoring
	SLO-2	Machine Condition Monitoring	Types of Ultrasonic Sensors and its Working Principle	Wavelet Packets	Neural Networks	Machine Tool Condition Monitoring
S-6	SLO-1	Condition Based Maintenance Activity	Different Types of Infra-Red Sensors	Vibration Signatures of Faults in Rotating Machines	Fuzzy Logic	Machine Learning Vs Deep Learning

Duration (hour)		Introduction to Condition Monitoring	Instrumentation	Signal processing	Pattern Recognition	Application and case studies of condition monitoring
		09	09	09	09	09
	SLO-2	*Condition Based Maintenance Activity*	*Working Principles of IR Sensor and its Key Application*	*Vibration Signatures of Faults in Rotating Machines*	*Fuzzy Logic*	*Machine Learning Vs Deep Learning*
S-7	SLO-1	*Transducer Selection and Location*	*Oil Analysis*	*Vibration Signatures of Faults in Reciprocating Machines*	*Support Vector Machines (SVM)*	*Machine Learning Vs Artificial Intelligence*
	SLO-2	*Transducer Selection and Location*	*Thermography*	*Vibration Signatures of Faults in Reciprocating Machines*	*Proximal Support Vector Machines (PSVM)*	*Machine Learning Vs Artificial Intelligence*
S-8	SLO-1	*PC Interfacing and Virtual Instrumentation*	*Motor Current Analysis*	*Detection and Diagnosis of Faults*	*Regression- Linear*	Machine Learning Applications Across Industries
	SLO-2	*PC Interfacing and Virtual Instrumentation*	*Motor Current Analysis*	*Detection and Diagnosis of Faults*	*Regression- Linear*	Machine Learning Applications Across Industries
S-9	SLO-1	*Data Driven Approach in Machine Learning*	*, Data Acquisition System (DAQ)*	*Classification and Regression*	*Regression- Polynomial*	*Tutorial*
	SLO-2	*Model Driven Approach in Machine Learning*	*Signal Conditioning*	*Classification and Regression*	*Regression- Polynomial*	*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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40 %	-	30 %	-	30 %	-	30 %	-	*30%*	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	*40%*	-
	Analyze										
Level 3	Evaluate	20 %	-	30 %	-	30 %	-	30 %	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.JeganAmirthalingam, Senior Educator, KPIT <a.jegan@kpit.com>*	*1. Dr. P. SathishKumar,Jiangsu University, China sathishkumar8989@gmail.com*	*1. Dr. T. Praveenkumar, SRMIST*
		2. Mr. E. Joshua Paul, SRMIST

Course Code	18AUE202T	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 sensors signals*
CLR-5 :	*Compare the input signals and select appropriate data conversion methods.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Acquire the knowledge of construction and operation of sensors and its applications in automobiles*	*1,2*	*90*	*85*	*H*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*M*	*L*
CLO-2 :	*Understand the basics of actuators and its operations*	*1,2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*L*
CLO-3 :	*Know the fundamentals of signals conditioning and devices and its operation*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-4 :	*Applications of operational amplifier and its applications*	*3*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-5 :	*Learn and implement the basics of data conversion devices*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*L*

Duration (hour)		Automotive Sensors	Automotive Actuators	Introduction To Op-Amp	Operational Amplifier Applications	Waveform Generators, A/D And D/A Convertors
		9	9	9	9	9
S-1	SLO-1	*Introduction to sensors*	*Basics of actuators and its principles of operations.*	*Introduction – Signal conditioning operations.*	*Applications of operational amplifiers*	*Comparator introduction*
	SLO-2	*Variables to be measured for automotive Engine control applications*	*Variables to be controlled for automotive Engine control applications.*	*Basics of operational amplifier*	*Basics of Instrumentation amplifiers*	*Comparator Applications*
S-2	SLO-1	*Airflow Rate Sensor – Construction and operations*	*Pulse width Modulated signal*	*Ideal operational amplifier Introduction*	*Operational amplifier using diodes- Half wave*	*Regenerative Comparator Introduction*
	SLO-2	*Pressure Measurement – Strain Gauge and MAP sensor*	*H-bridge device for speed and direction control.*	*Ideal operational amplifier characteristics*	*Full wave rectifiers*	*Square Wave Generator*
S-3	SLO-1	*Engine Crank Position sensor - -Magnetic reluctance,*	*Electric motor actuator - DC motor, Brushless DC Motor*	*Operational amplifier- open and closed loop*	*Precision diodes*	*Astable Multivibrator*
	SLO-2	*Hall effect sensor Construction and Operation*	*Stepper Motor mechanism*	*Operational amplifier- Inverting, Non-Inverting amplifier.*	*Sample and Hold circuits*	*Monostable Multivibrator*
S-4	SLO-1	*Optical crank position Construction and Operation*	*Servomechanism*	*Voltage follower*	*Voltage to Current converters*	*Bistable Multivibrator*
	SLO-2	*Throttle angle sensor construction and operations.*	*Engine control actuators -Fuel injector*	*Differential amplifier*	*Current to Voltage converters*	*Introduction to Analog to Digital Converters*
S-5	SLO-1	*Temperature Sensor construction and operations and types.*	*Ignition coil operation*	*Difference mode gain*	*Applications of operational amplifiers as Adder*	*Types of Analog to Digital Converters*

Duration (hour)		Automotive Sensors	Automotive Actuators	Introduction To Op-Amp	Operational Amplifier Applications	Waveform Generators, A/D And D/A Convertors
		9	9	9	9	9
	SLO-2	*Sensors for Engine feedback control - EGO sensor, EGO characteristics*	*EGR Actuator operation*	*Common mode gain*	*Applications of operational amplifiers as Subtractor*	*Direct Type ADC – Flash Type*
S-6	SLO-1	*White Band Lambda sensor*	*Electric actuators- Introduction.*	*Common Mode Rejection Ratio*	*Applications of operational amplifiers as Multiplier*	*Direct Type ADC – Successive approximation type*
	SLO-2	*Magnetostrictive principle and Knock sensor*	*Relays – Construction and Operation*	*Operation amplifier internal circuit*	*Applications of operational amplifiers as divider*	*Numerical Examples for ADC*
S-7	SLO-1	*Oil Pressure sensors*	*Reed switches - Construction and Operation*	*DC characteristics of operational amplifier*	*Applications of operational amplifiers as Differentiator*	*Basics of Digital to Analog Conversion Techniques*
	SLO-2	*Accelerometer construction and operations*	*Actuators applications*	*IC 741 internal circuit Introduction*	*Applications of operational amplifiers as Integrator*	*R-2R Ladder DAC*
S-8	SLO-1	*Gyro sensors construction and operations*	*Electric Power Assisted Steering*	*IC 741 Operations*	*Instrumentation amplifier application*	*Inverted R-2R Ladder DAC*
	SLO-2	*Inertial measurement unit*	*Rain sensing wipers*	*Filters – Introduction*	*Instrumentation amplifier application. Cont*	*Weighted Resistor type DAC*
S-9	SLO-1	*Sensors for climate control*	*Motorized seat position control*	*High pass and low pass Filter*	*Voltage comparator*	*Numerical Examples for weighted resistor*
	SLO-2	*Switches and Knobs*	*Power Window application*	*Band pass Filter*	*Peak detector*	*Numerical Examples for R-2R and Inverted R-2R*

Learning Resources	1. *William. B. Ribbens, "Understanding Automotive Electronics" 8th Edition Butterworth-Heinemann publications, 2017.* 2. *Ronald. K. Jurgan "Automotive Electronics Handbook", 2nd Edition , McGraw-Hill, Inc 1999*	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 Age International Pvt. Ltd., 2000* 5. *Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 3rd Edition, Tata Mc Graw-Hill, 2007.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com*	*1. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*1. Mr. N Ganesh Kumar, SRMIST*
2. *Mr.G.Giri Atalon giri@atalon.co.in*		*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE317J	Course Name	AUTOMOTIVE CONTROL ENGINEERING	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 :	*Familiarize about the importance of feedback control in automotive applications*
CLR-2 :	*Understand the status of the system in terms of stability*
CLR-3 :	*Develop the knowledge of controller and compensator design*
CLR-4 :	*Familiarize and execute stability analysis on linear system*
CLR-5 :	*Understand the concept of frequency response and analyze feedback systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Find the transfer function for linear control systems .*	*2*	*85*	*75*	*H*	*M*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Perform time response analysis for standard prototyping systems.*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Perform stability analysis for the system under study*	*2*	*90*	*85*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Apply frequency analysis for the system under study*	*2*	*85*	*80*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Design and implement controllers and compensators for the system under study*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		Introduction to Feedback Systems	Performance of Feedback Systems	Stability Analysis of Linear System	Frequency Response Analysis of Feedback Systems	Controller Design for Linear Feedback System
		12	12	12	12	12
S-1	SLO-1	*Introduction to Systems and its types*	*Introduction to time response analysis*	*Introduction to the Concept of Stability*	*Introduction to Frequency response*	*Introduction to controllers P,PI,PD,PID*
	SLO-2	*Examples of automotive feedback systems*	*Transient response and steady state response*	*Bounded-input, Bounded-output stability(BIBO)*	*Sinusoidal excitation and response to a system*	*Effect of Proportional, Integral and differentiator constants*
S-2	SLO-1	*ADAS, Engine Management system*	*Sensitivity of a feedback system*	*Routh –Hurwitz stability criterion*	*Introduction to Frequency response plots and performance specification*	*PID design for an automotive feedback system*
	SLO-2	*Linear Time invariant systems*	*Standard test inputs for feedback system analysis*	*Routh –Hurwitz stability - Basic Numerical Problems*	*Bode plot - constant gain*	*Frequency domain interpretation of PID controller*
S 3-4	SLO-1	*Lab 1:Introduction To Matlab Control System Tool Box, Simulink Tool Box*	*Lab 3: Simulation of cruise control example using Matlab Simulink*	*Lab 5: Stability analysis of Second Order UnityFeedback System using Matlab control system toolbox.*	*Lab 7: Determination Of Bode Plot Using Matlab Control System Toolbox for 2nd Order System & Obtain Controller Specification Parameters.*	*Lab 9: Implementantion of Proportional-Integral-Derivative (PID) controller using Matlab Control System Toolbox.*
	SLO-2					
S-5	SLO-1	*Parameter varying system and Nonlinear system*	*Transient response and steady state response - Numerical Problems*	*Routh – Hurwitz stability - Basic Numerical Problems Cont.*	*Bode plot - differentiator ,integrator and second order term*	*Frequency domain interpretation of PID controller*
	SLO-2	*Impulse response of a system and transfer function representation*	*Time response analysis of a first order prototyping system*	*Routh – Hurwitz stability in controller parameter selection*	*Phase Margin and Gain Margin fundamentals*	*PID Numerical Problems*
S-6	SLO-1	*Transfer function of a D.C motor*	*Time response analysis of First order prototyping system - Numerical Problems*	*Stability analysis of tracked vehicle turning control*	*Procedure to plot bode diagram – Gain margin,Phase margin and stability conditions*	*Lead compensator,Lag compensator*
	SLO-2	*Transfer function of Throttle position sensor, Velocity Sensor,Accelerometer Model*	*Time response analysis - Cruise control model*	*Stability analysis of tracked vehicle turning control Cont.*	*Bode Diagram - Numerical Problems*	*Lead Lag compensators Numerical Examples*

Duration (hour)		Introduction to Feedback Systems	Performance of Feedback Systems	Stability Analysis of Linear System	Frequency Response Analysis of Feedback Systems	Controller Design for Linear Feedback System
		12	12	12	12	12
S 7-8	SLO-1	*Lab 1: Transfer Function - DC Motor Speed control Simulink Modeling,*	*Lab 4:Simulation of suspension system in Matlab Simulink*	*Lab 6: Determination Of Root Locus Plot And Controller Specifications Using Matlab Control SystemToolbox*	*Lab 8: Determination Of Nyquist Plot Using Matlab Control System Toolbox.*	*Lab 10: Designing Compensators using Matlab Simulink*
	SLO-2					
S-9	SLO-1	*Introduction to Block diagram algebra*	*Time response analysis of second order prototyping system*	*The Root locus procedure for stability analysis*	*.Polar Plot - Overview*	*Design of phase lead and phase lag compensation*
	SLO-2	*Block diagram algebra Numerical examples*	*Time response analysis of second order prototyping system - Numerical Problems*	*Root locus Analysis - Basic Problems*	*.Polar Plot - Numerical Problems*	*Time domain and frequency domain interpretation of design of phase lead and phase lag compensation*
S-10	SLO-1	*Introduction to Signal Flow Graph*	*Complex Plane root location and transient response*	*Root locus Analysis of speed control system*	*Nyquistcriterion for non-minimum phase system*	*Notch Filter*
	SLO-2	*Signal Flow Graph numerical problems*	*Steady state error of feedback control system - Numerical Problems*	*Controller design using root locus for a closed loop control system- Numerical Example*	*Nyquistcriterin for non-minimum phase system*	*Notch Filter Numerical Problems*
S 11-12	SLO-1	*Lab: Assessment 1*	*Lab: Assessment 2*	*Lab: Assessment 3*	*Lab: Review class*	*Lab: Mini Project*
	SLO-2					

Learning Resources		
1. *Richard.C.Dorf and Robert.H.Bishop, "Modern Control System" 12th edition Pearson Prentice Hall,2013.*	2. *Benjamin.C.Kuo, "Automatic control systems", Prentice Hall of India, 7th Edition,1995*	3. *P N J.Nagrath and M.Gopal, "Control System Engineering", New Age International Publishers, 5th Edition, 2007.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20 %*	*20 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Understand										
Level 2	Apply	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*
	Analyze										
Level 3	Evaluate	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Dr. Teoh Yew Heng, University Sains, Malaysia,yewhengteoh@usm.my*	*1. Mr.Jesu Godwin D, SRMIST*
	2. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in	*2. Mr. E. Joshua Paul, SRM IST*

Course Code	18AUE202T	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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 Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Acquire the knowledge of construction and operation of sensors and its applications in automobiles*	*1,2*	*90*	*85*
CLO-2 :	*Understand the basics of actuators and its operations*	*1,2*	*90*	*85*
CLO-3 :	*Know the fundamentals of signal conditioning devices and its operation*	*2*	*90*	*85*
CLO-4 :	*Applications of operational amplifier and its applications*	*3*	*85*	*80*
CLO-5 :	*Learn and implement the basics of data conversion devices*	*2*	*85*	*80*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*H*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*M*	*L*
CLO-2 :	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*L*
CLO-3 :	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-4 :	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*L*
CLO-5 :	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*L*

Duration (hour)		Automotive Sensors	Automotive Actuators	Introduction To Op-Amp	Operational Amplifier Applications	Waveform Generators, A/D And D/A Convertors
		9	9	9	9	9
S-1	SLO-1	*Introduction to sensors*	*Basics of actuators and its principles of operations.*	*Introduction – Signal conditioning operations.*	*Applications of operational amplifiers*	*Comparator introduction*
	SLO-2	*Variables to be measured for automotive Engine control applications*	*Variables to be controlled for automotive Engine control applications.*	*Basics of operational amplifier*	*Basics of Instrumentation amplifiers*	*Comparator Applications*
S-2	SLO-1	*Airflow Rate Sensor – Construction and operations*	*Pulse width Modulated signal*	*Ideal operational amplifier Introduction*	*Operational amplifier using diodes- Half wave Rectifier*	*Regenerative Comparator Introduction*
	SLO-2	*Pressure Measurement – Strain Gauge and MAP sensor*	*H-bridge device for speed and direction control.*	*Ideal operational amplifier characteristics*	*Full wave rectifiers*	*Square Wave Generator*
S-3	SLO-1	*Engine Crank Position sensor - -Magnetic reluctance,*	*Electric motor actuator - DC motor, Brushless DC Motor*	*Operational amplifier- open and closed loop*	*Precision diodes*	*Astable Multivibrator*
	SLO-2	*Hall effect sensor Construction and Operation*	*Stepper Motor mechanism*	*Operational amplifier- Inverting, Non-Inverting amplifier.*	*Sample and Hold circuits*	*Monostable Multivibrator*
S-4	SLO-1	*Optical crank position Construction and Operation*	*Servomechanism*	*Voltage follower*	*Voltage to Current converters*	*Bistable Multivibrator*
	SLO-2	*Throttle angle sensor construction and operation.*	*Engine control actuators -Fuel injector*	*Differential amplifier*	*Current to Voltage converters*	*Introduction to Analog to Digital Converters*
S-5	SLO-1	*Temperature Sensor construction and operations and types.*	*Ignition coil operation*	*Difference mode gain*	*Applications of operational amplifiers as Adder*	*Types of Analog to Digital Converters*

Duration (hour)		Automotive Sensors	Automotive Actuators	Introduction To Op-Amp	Operational Amplifier Applications	Waveform Generators, A/D And D/A Convertors
		9	9	9	9	9
	SLO-2	*Sensors for Engine feedback control - EGO sensor, EGO characteristics*	*EGR Actuator operation*	*Common mode gain*	*Applications of operational amplifiers as Subtractor*	*Direct Type ADC – Flash Type*
S-6	SLO-1	*Wide Band Lambda sensor*	*Electric actuators - Overview*	*Common Mode Rejection Ratio*	*Applications of operational amplifiers as Multiplier*	*Direct Type ADC – Successive approximation type*
	SLO-2	*Magnetostrictive principle and Knock sensor*	*Relays – Construction and Operation*	*Operation amplifier internal circuit*	*Applications of operational amplifiers as divider*	*Numerical Examples for ADC*
S-7	SLO-1	*Oil Pressure sensors*	*Reed switches - Construction and Operation*	*DC characteristics of operational amplifier*	*Applications of operational amplifiers as Differentiator*	*Basics of Digital to Analog Conversion Techniques*
	SLO-2	*Accelerometer construction and operations*	*Actuators applications*	*IC 741 internal circuit Introduction*	*Applications of operational amplifiers as Integrator*	*R-2R Ladder DAC*
S-8	SLO-1	*Gyro sensors construction and operations*	*Electric Power Assisted Steering*	*IC 741 Operations*	*Instrumentation amplifier application*	*Inverted R-2R Ladder DAC*
	SLO-2	*Inertial measurement unit*	*Rain sensing wipers*	*Filters – Introduction*	*Instrumentation amplifier application. Cont*	*Weighted Resistor type DAC*
S-9	SLO-1	*Sensors for climate control*	*Motorized seat position control*	*High pass and low pass Filter*	*Voltage comparator*	*Numerical Examples for weighted resistor*
	SLO-2	*Switches and Knobs*	*Power Window application*	*Band pass Filter*	*Peak detector*	*Numerical Examples for R-2R and Inverted R-2R*

Learning Resources	1. *William. B. Ribbens, "Understanding Automotive Electronics" 8th Edition Butterworth-Heinemann publications, 2017.* 2. *Ronald. K. Jurgan "Automotive Electronics Handbook", 2nd Edition , McGraw-Hill, Inc 1999* 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 Age International Pvt. Ltd., 2000* 5. *Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 3rd Edition, Tata Mc Graw-Hill, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*1. Mr. N Ganesh Kumar, SRMIST*
2. Mr.G.Giri Atalon giri@atalon.co.in		*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE211J	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 of about the BJT,MOS based amplifiers*
CLR-2 :	*Know the working of oscillator and 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 Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understanding the use of analog circuits that are essential for Automotive Application*	*2*	*85*	*75*	*H*	*M*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Understand the Oscillators, Wave Shaping and Multi Vibrator Circuits*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Apply the Minimization Techniques and understand Digital Logic Gates*	*2*	*90*	*85*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Design and implement the Combinational Circuits*	*2*	*85*	*80*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Design and implement Sequential Circuits and understand the Memory Devices*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		Introduction to Analog Circuits	Oscillators, Wave Shaping and Multi Vibrator Circuits	Digital Logic Gates and Minimization Techniques	Combinational Circuits	Sequential Circuits and Memory Devices
		12	12	12	12	12
S-1	SLO-1	*Introduction to Analog circuits*	*Oscillator Introduction*	*AND,OR Logic circuit implementation*	*Introduction to Combinational Circuit*	*Latches, Flip-flops –SR,JK,D,T characteristic table and Equation*
	SLO-2	*BJT Small signal Model*	*Analysis of LC oscillator*	*NOT Logic circuit implementation*	*Half Adder and Full Adder*	*Asynchronous Counters*
S-2	SLO-1	*CMOS Circuit Model*	*Active RC,RL Filters*	*NAND,NOR Logic circuit implementation*	*Half Subtractor and Full Subtractor*	*Synchronous Counters*
	SLO-2	*CMOS Circuit Model*	*RC,RL integrator*	*EXOR, EX-NOR Logic circuit implementation*	*Adder and Subtractor circuit example*	*Programmable Counters*
S 3-4	SLO-1 SLO-2	*Lab 1: basic Digital IC's AND,OR,EXOR,NOT,NOR,NAND*	*Lab 3: Combination Logic Adder, Subtractor*	*Lab 5: Realization of Encoder, Decoder*	*Lab 7: Op-Amp Linear Application :Adder, Subtractor*	*Lab 9: Op-Amp Nonlinear Application : Clipper, Clamper, Peak Detector*
S-5	SLO-1	*Biasing Circuits*	*Differentiator Circuits*	*TTL Logic*	*Carry look ahead adder*	*Registers overview*
	SLO-2	*Biasing Circuits*	*Diode-Clippers*	*CMOS Logic*	*Serial adder/Subtractor*	*Shift Registers*
S-6	SLO-1	*MOS amplifiers*	*Diode Clamper*	*Boolean Postulates*	*BCD addition*	*Universal Shift Register*
	SLO-2	*MOS amplifiers - types*	*Diode Comparator*	*Demorgan's Theorem*	*Multiplexer*	*Sequence Generator*
S 7-8	SLO-1 SLO-2	*Lab 2: Circuit realization of Flip-flops JK , RS , D*	*Lab 4: Circuit realization of Code Converter*	*Lab 6: Circuit realization of MUX,DEMUX*	*Lab 8: Op-Amp Linear Application : Comparator, Differentiator, Integrator*	*Lab 10: Filters Realization*
S-9	SLO-1	*Frequency response of amplifiers*	*UJT-Sawtooth Waveform Generator*	*Min term, Max term*	*Demultiplixer*	*Classification of Memories – RAM,ROM,PROM,EPROM,EEPROM*
	SLO-2	*Frequency response of amplifiers*	*Astable, MonostableMultivibrators*	*POS,SOP form*	*Decoder, Encoder*	*RAM,ROM Organization*
S-10	SLO-1	*Differential amplifiers*	*BistableMultivibrator*	*K-MAP*	*Parity Checker, Parity Generator*	*PLA VS PLD – Combinational Circuit implementation*
	SLO-2	*Differential amplifiers. Cont*	*Schmitt trigger circuits*	*Don't care conditions*	*Code Convertor*	*Introduction to FPGA*
S 11-12	SLO-1 SLO-2	*Lab: Assessment 1*	*Lab: Assessment 2*	*Lab: Assessment 3*	*Lab: Repeat class*	*Lab: Mini Project*

Learning Resources	1. *David A.Bell "Electronic Devices and Circuits", Oxford Higher Education Press, 5th Edition, 2010* 2. *M. Morris Mano, "Digital Design", 4th Edition, Prentice Hall of India Pvt. Ltd., 2008 / Pearson Education (Singapore) Pvt. Ltd., New Delhi.*	3. *Donald P.Leach and Albert Paul Malvino, "Digital Principles and Applications", 6th Edition, TMH, 2006.* 4. *Sedra and Smith, "Micro Electronic Circuits"; Sixth Edition, Oxford University Press, 2011. Millman and Halkias. C., Integrated Electronics, TMH, 2007.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20 %*	*20 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Understand										
Level 2	Apply	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*
	Analyze										
Level 3	Evaluate	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*1. Mr. Joshua Paul E, SRMIST* *2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE311T	Course Name	PRINCIPLES OF LINEAR SYSTEMS AND SIGNALS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*18AEE211J*	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 and classify the signals, their operations and the systems*
CLR-2 :	*Test and execute the continuous time system's response, stability in time domain.*
CLR-3 :	*Formulate and solve the continuous time system equations using Laplace transform.*
CLR-4 :	*Solve and examine the discrete time system using Z transform*
CLR-5 :	*Execute the Fourier series based representation of continuous time signal systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Acquire the fundamentals of signal operation andbasics of system*	*1*	*90*	*85*
CLO-2 :	*Perform time domain analysis of a continuous time system with various inputs.*	*2*	*85*	*80*
CLO-3 :	*Analyse and examine the Continuous Time System in frequency domain using Laplace transform.*	*2,3*	*85*	*80*
CLO-4 :	*Test the stability and the response of discrete time system using Z transform*	*2,3*	*85*	*80*
CLO-5 :	*Know the fundamentals involved in continuous time signal analysis*	*2*	*85*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
H	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*

Duration (hour)		Signals and Systems	Time Domain Analysis of Continuous Time Systems	Continuous Time System Analysis Using Laplace Transform	Discrete Time Analysis Using Z-Transform	Continuous Time Signal Analysis
		09	09	09	09	09
S-1	SLO-1	*Size of a signal – Signal Energy*	*System response to internal condition– Zero input response*	*Laplace transform – Inverse Laplacetransform*	*Z-Transform introduction*	*Periodic signal representation by trigonometric Fourier series*
	SLO-2	*Size of a signal –Signal Power*	*System response to internal condition – Zero input response.*	*Properties of the Laplace transform – Time shifting*	*Finding inversetransform*	*Periodic signal representation by trigonometric Fourier series - The Fourier spectrum*
S-2	SLO-1	*Signal Operations –Time shifting, Time scaling*	*Unit Impulse response*	*Properties of the Laplace transform – frequency shifting*	*Properties of Z-transform*	*Periodic signal representation by trigonometric Fourier series - The Fourier spectrum.*
	SLO-2	*Signal Operations – Time reversal, combined operation*	*Impulse response.*	*Properties of the Laplace transform – time differentiation property*	*Z-transform solution of linear difference equations – Zero-state response of LTID system*	*Periodic signal representation by trigonometric Fourier series - Effect of symmetry*
S-3	SLO-1	*Classification of signals – Continuous-Time.*	*System response to external input – Zero state response*	*Properties of the Laplace transform – time integration property.*	*Z-transform solution of linear difference equations – Stability and Inversesystem*	*Periodic signal representation by trigonometric Fourier series - Determining the Fundamental Frequency and Period*
	SLO-2	*Classification of signals –Discrete-time signals*	*System response to external input – Zero state response.*	*Properties of the Laplace transform – Time convolution*	*Z-transform solution of linear difference equations – Stability and Inversesystem*	*Existences and Convergence of Fourier series*
S-4	SLO-1	*Classification of signals –Analog and Digital signals*	*System response to external input – Convolution integral*	*Properties of the Laplace transform – frequency convolution*	*System Realization*	*Existences and Convergence of Fourier series.*
	SLO-2	*Classification of signals –Periodic and Aperiodic signals,*	*System response to external input – Convolution integral*	*Solution of differential and integro - differential equation –Zero state response*	*System Realization.*	*Exponential Fourier series - Exponential Fourier spectra*
S-5	SLO-1	*Classification of signals - Energy and Power signals,*	*System response to external input – Interconnected systems*	*Solution of differential and integro - differential equation –Zero state response.*	*Frequency response of discrete time systems – Periodic nature of frequency response*	*Exponential Fourier series- Exponential Fourier spectra.*

Duration (hour)		Signals and Systems	Time Domain Analysis of Continuous Time Systems	Continuous Time System Analysis Using Laplace Transform	Discrete Time Analysis Using Z-Transform	Continuous Time Signal Analysis
		09	09	09	09	09
	SLO-2	*Classification of signals – Deterministic and Randomsignals*	*System response to external input – Interconnected system.*	*Solution of differential and integro-differential equation – stability*	*Frequency response of discrete time systems – Periodic nature of frequency response.*	*Exponential Fourier series - Parseval's theorem*
S-6	SLO-1	*Excitation signals- Unit Step function*	*System stability –Internal Asymptoticstability*	*Solution of differential and integro - differential equation – Inverse system*	*Frequency response of discrete time systems – Aliasing andsampling rate*	*LTI System response to periodic inputs*
	SLO-2	*Excitation signals-Unit impulse function and Exponential function*	*System stability –Internal Asymptoticstability.*	*System Realization -Introduction*	*Frequency response of discrete time systems –Aliasing andsampling rate.*	*LTI System response to periodic inputs.*
S-7	SLO-1	*Even functions and Odd functions-Properties*	*Relationship between BIBO and asymptotic stability.*	*System realization - Direct Form I Realization*	*Frequency response from pole-zero location*	*Aperiodic signal representation by Fourier integral*
	SLO-2	*Classification of system – Linear and nonlinear systems,*	*Relationship between BIBO and asymptotic stability.*	*System realization - Direct Form II Realization*	*Frequency response from pole-zero Location.*	*Aperiodic signal representation by Fourier integral.*
S-8	SLO-1	*Classification of system –Time invariant, time varying*	*Dependence of system behavior on characteristics modes*	*Analysis of a simple feedback control system*	*Relationship between Laplace transform and z-transform*	*Relationship between the Fourier and Laplace transform*
	SLO-2	*Classification of system – Instantaneous and dynamic*	*Dependence of system behavior on characteristics modes.*	*Analysis of a simple feedback control system.*	*Relationship between Laplace transform and z-transform.*	*Relationship between the Fourier and Laplace transform.*
S-9	SLO-1	*Classification of system – causal and non-causal system*	*Response time of system –time constant, rise time*	*Frequency response of an LTIC System*	*Bilateral Z-transform -Introduction*	*Properties of Fourier transform*
	SLO-2	*Classification of system –Analog and Digital system*	*Response time of system –resonance Phenomenon.*	*Frequency response of an LTIC system.*	*Bilateral Z-transform -Properties*	*Properties of Fourier transform.*

Learning Resources	
1. *B.P. Lathi "Principles Of Linear Systems And Signals "Oxford University Press, 2009.*	3. *R.E.Zeimer, W.H.Tranter and R.D.Fannin, "Signals & Systems - Continuous and Discrete", Pearson, 2007.*
2. *Allan V.Oppenheim, S.Wilsky and S.H.Nawab, "Signals and Systems", Pearson, 2007.*	

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
	Analyze										
Level 3	Evaluate	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com*	1. *Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	1. *Ms. Srividya K, SRMIST*
	2. *Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com*	2. *Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE312T	Course Name	AUTOMOTIVE INFOTRONICS	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 :	*State and classify the various driver and vehicle support systems.*
CLR-2 :	*Interpret and construct the vehicle communication systems according to the requirement*
CLR-3 :	*Differentiate and construct the various automotive safety systems*
CLR-4 :	*Develop and examine the comfort suitable for the driver's convenience*
CLR-5 :	*Investigate and test the required security for the vehicles*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool ...	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Define and identify the driver convenience, perception and general vehicle control*	*1*	*90*	*85*	*H*	*M*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	*H*	*H*	*M*	*M*
CLO-2 :	*Solve and implement the sensors, their modelling for the vehicle communication systems*	*2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*
CLO-3 :	*Relate and formulate the required safety systems for the required vehicle model.*	*2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*H*	*M*
CLO-4 :	*Examine and value the relationship between driver and vehicle in comfort perspective.*	*2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*H*	*M*
CLO-5 :	*Design and experiment the automotive security systems for its performance*	*2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*H*	*H*

Duration (hour)		Driver and vehicle support systems - Introduction	Automotive Telematics	Infotronics for Automotive safety systems	Infotronics for Automotive comfort systems	Infotronics for Automotive security systems
		09	09	09	09	09
S-1	SLO-1	*Driver information - navigation routing, integrated navigation*	*Global positioning system – Basics and working*	*Active and passive safety systems - Introduction*	*Adaptive cruise control system*	*Anti-theft technologies – mechanical, electromechanical*
	SLO-2	*Real-time traffic, traveller information*	*Geographical information systems - Data representations*	*Active and passive safety systems - Features*	*Active suspension system*	*Anti-theft technologies – Electronic immobilizers*
S-2	SLO-1	*Driver perception - vision enhancement, electronic mirror*	*Geographical information systems - Analysis and modeling*	*Airbag System - components*	*Aadjustable ORVMs*	*Alarm and warning system*
	SLO-2	*Parking and reversing aid, state of the road surface systems*	*geographical information systems – Applications*	*Airbag System - Working*	*Electrical Power assisted steering*	*Stolen vehicle tracking system*
S-3	SLO-1	*Driver convenience-driver identification, hands – free and remote control*	*Signpost navigation system*	*Seat belt tightening system- Block diagram*	*Collapsible and tiltable steering column*	*Remote keyless entry*
	SLO-2	*Driver convenience - automated transactions*	*Dead reckoning navigation system*	*seat belt tightening system- Working*	*Power windows*	*Smart card system*
S-4	SLO-1	*Driver monitoring - driver vigilance monitoring*	*Automotive vision system*	*Forward collision warning system- Block diagram*	*Adaptive lighting system*	*Number plate recoginition*
	SLO-2	*Driver health monitoring*	*Intelligent Speed Adaptation system*	*Forward collision warning system- Working*	*Electrically adjustable seats*	*Security antenna and transponders*
S-5	SLO-1	*General vehicle control - automatic stop and go*	*Fleet Tracking system*	*Child lock and anti-lock braking system- Block diagram*	*Rain sensing Wiper systems*	*Electronic ignition lock*
	SLO-2	*Vehicle Platooning*	*Voice based Turn-by-Turn system*	*Child lock and anti-lock braking system- Working*	*Reverse parking camera*	*Radio security system*
S-6	SLO-1	*Longitudinal control - road and lane departure collision avoidance*	*Smart-phone App Integration*	*Electronic Brake force Distribution system- Block diagram*	*Hands free Bluetooth*	*Fingerprint vehicle unlock*

Duration (hour)		Driver and vehicle support systems - Introduction	Automotive Telematics	Infotronics for Automotive safety systems	Infotronics for Automotive comfort systems	Infotronics for Automotive security systems
		09	09	09	09	09
	SLO-2	*Longitudinal control - road and lane departure collision avoidance Cont.*	*Automotive Collision Notification system*	*Electronic Brake force Distribution system- Working*	*Automatic Temperature control*	*GPS security systems*
S-7	SLO-1	*Lateral control - lane change and merge collision avoidance*	*Integrated theft recovery system*	*Electronic Stability Programme- Block diagram*	*Connected Mobility assistance and telematics*	*Speed governing systems*
	SLO-2	*Lane change and merge collision avoidance .Cont*	*Intelligent Speed Adaptation system*	*Electronic Stability Programme- Working*	*USB charging and navigation systems*	*Vehicle tracking systems*
S-8	SLO-1	*rear-end collision avoidance, \obstacle and pedestrian detection*	*Intelligent Speed Adaptation system .Cont*	*Traction control system - Block diagram*	*Intelligent windshield wipers*	*Anti-hijack system*
	SLO-2	*Intersection collision warning*	*Voice recognition cell phone dialing system*	*Traction control system - Working*	*Intelligent windshield wipers*	*Vehicle Immobilizer*
S-9	SLO-1	*Vehicle monitoring - tachograph*	*Voice recognition cell phone dialing system*	*Lane departure warning system- Block diagram*	*Adaptive climate control*	*Steering-wheel lock*
	SLO-2	*Vehicle monitoring - alerting systems, vehicle diagnostics*	*Emergency calling system*	*Lane departure warning system- Working*	*Adaptive climate control.*	*Vehicle GPS tracking*

Learning Resources	
1. *LjuboVlacic, Michel Parent and Fumio Harashima, "Intelligent Vehicle Technologies", Butterworth-Heinemann publications, Oxford, 2001.* 2. *Robert Bosch, "Automotive Hand Book", SAE, 2000.* 3. *Allan W M B, "Automotive Computer Controlled Systems", Elsevier Butterworth-Heinemann, 2011.*	4. *Ronald K Jurgen, "Navigation and Intelligent Transportation Systems – Progress in Technology", Automotive Electronics Series, SAE, USA, 1998.* 5. *William B R, "Understanding Automotive Electronics", Butter worth Heinemann Woburn, 1998.* 6. *Bechhold, "Understanding Automotive Electronics", SAE, 1998.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*1. Mr. Srividya K, SRMIST*
2. Mr.G.Giri Atalon giri@atalon.co.in		*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE313T	Course Name	ARTIFICIAL NEURAL NETWORKS AND FUZZY LOGIC	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Define and understand the concept of Neural Network Models and Learning algorithm.*			
CLR-2 :	*Understand the concepts and implementation of fuzzy logic and fuzzy logic controllers.*			
CLR-3 :	*Interpret and relate the Fuzzy Sets And Fuzzy Relations.*			
CLR-4 :	*Compare and contrast the Hybrid fuzzy systems such as Neuro fuzzy systems with classical systems.*			
CLR-5 :	*Understand the implementation of Fuzzy and neuro systems in hardware.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*List and recognize the various Fuzzy systems in automobile applications.*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Identify and Estimate Parameters of a system through Fuzzy Logic and Neural Networks*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-3 :	*Identify and use various Fuzzy sets and Fuzzy Relations*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Relate and use the various fuzzy logic and fuzzy logic controllers.*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-5 :	*Select and Investigate on the various Neural Network Models.*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		Introduction To Neural Networks	Neural Network Models and Application	Fuzzy Sets And Fuzzy Relations	Embedded Fuzzy Application	Hybrid Fuzzy-Neuro Systems And Hardware Implementation
		09	09	09	09	09
S-1	SLO-1	*Introduction to ANN*	*Neural Network-Feed Forward Application*	*Basic Concepts of Classical Sets*	*Introduction to conventional Control System*	*Introduction to Hybrid Systems*
	SLO-2	*Components of ANN-Connection, weights, biases*	*Neural Network-Back Propagation Network Application*	*Set Operation, Boolean Logic*	*Description, Design and Analysis*	*Fuzzy Neuron Overview*
S-2	SLO-1	*Structure of Neural Network*	*Layers In Neural Network-Single Layer*	*Basics of Fuzzy Sets*	*PID controller*	*Multilayer FNN architectures XOR Problem*
	SLO-2	*Structure of Neural Network.*	*Layers In Neural Network- Multilayer*	*Representation of Fuzzy Sets*	*Introduction to Fuzzy logic Controller (FLC)*	*Types of decision Region*
S-3	SLO-1	*Output of a Neuron*	*XOR Function and Linear Separability*	*Fuzzy Membership Function*	*Fuzzy logic Controller (FLC)- Description, Design*	*FNN Neuron Model*
	SLO-2	*Propagation functions, Learning Rules*	*XOR Function and Linear Separability.*	*Trapezoidal, Gaussian and Its Determination*	*Membership values, Rule table*	*Fuzzy ART, Fuzzy ARTMAP*
S-4	SLO-1	*Supervised and unsupervised learning*	*Threshold Functions-Sigmoid Function, Step Function*	*Fuzzy Set Properties, Operations*	*Membership values invented pendulum case study*	*Fuzzy ARTMAP- Incremental supervised Learning*
	SLO-2	*Reinforced Learning*	*Ramp Function And Linear Function*	*Logic Operation And Algebraic Operations.*	*Fuzzy logic Controller (FLC) – Knowledge base and Defuzzyification*	*Learning Normalized analog input patterns*
S-5	SLO-1	*Perception and Multilayer Perception*	*Function Approximation With Neural Networks*	*Classical Relations And Fuzzy Reasoning overview*	*Implementation of Antilock controller example*	*Neuro-Fuzzy systems*
	SLO-2	*Perception and Multilayer Perception.*	*Function Approximation With Neural Networks.*	*Fundamentals Of Fuzzy Relations*	*Fuzzy logic Controller (FLC) –Analysis with computer aided Tools*	*Neuro-Fuzzy applications*

Duration (hour)		Introduction To Neural Networks	Neural Network Models and Application	Fuzzy Sets And Fuzzy Relations	Embedded Fuzzy Application	Hybrid Fuzzy-Neuro Systems And Hardware Implementation
		09	09	09	09	09
S-6	SLO-1	*Feed forward Network and Hopfield Network.*	*System Identification With Neural Networks*	*Binary Fuzzy Relation operation*	*Fuzzy based antilock braking system overview*	*Neuro-Fuzzy systems Linguistic Fuzzy Model*
	SLO-2	*Introduction to Neural Network Models*	*Block Box Model Structure*	*Fuzzy Relations introduction*	*Fuzzy based antilock braking system.*	*Fuzzy Membership Fuzzy Rules, Fine-tune Fuzzy Rules*
S-7	SLO-1	*Neural Network Models –Adaline*	*Static Neural Network in system Identification*	*Types Of Fuzzy Relations*	*Performance and robustness of Fuzzy controller*	*Hardware Implementation –Analog Techniques*
	SLO-2	*Neural Network Models –Madaline*	*Dynamic Neural Network in system Identification*	*Membership Matrix*	*Self-Organizing Fuzzy controller*	*Hardware Implementation - Digital Techniques*
S-8	SLO-1	*Neural Network Models –Back propagation Network*	*Model Parameters estimation with Neural Network*	*Union and intersection of Fuzzy Relations*	*Fuzzy logic Controller for Automotive Embedded System applications.*	*Fuzzy Memory and OP-Amp based implementation of basic Neuron Model*
	SLO-2	*Radial basis function Neural Network*	*Control system and Neural Networks*	*Composition of Fuzzy Relations*	*Case study on Fuzzy logic Controller : Automatic Gearboxes*	*Fuzzy Memory and OP-Amp based implementation of basic Neuron Model.*
S-9	SLO-1	*Self-organizing, Recurrent Neural Network*	*Neural Networks in Predictive control*	*Fuzzy Reasoning- Fuzzy If-Then Rules*	*Case study on Fuzzy logic Controller : Four- wheel steering*	*Microcontroller Based Implementation of Fuzzy controller algorithm for automotive air conditioning Case study*
	SLO-2	*Convolution, Modular Neural Network*	*Model Reference Neural Controller*	*Fuzzy If-Then Rules.*	*Case study on Fuzzy logic Controller : Vehicle environment control*	*Microcontroller Based Implementation of Fuzzy controller algorithm for automotive air conditioning. Cont*

Learning Resources	
1. *Ahmad.M.Ibrahim "Fuzzy logic for Embedded System application" -Newness 2004,ISBN: 0-7506-7699* 2. *Valluru B.Rao " C++,Neural Network and Fuzzy logic"., -M&T Books ,IDG books Worldwide,ISBN1558515526* 3. *M.Gopal "Digital Control and State Variable Methods"-2nd edition, Tata McGraw Hill Publishing,2006*	4. *Simon Haykin", Neural Networks and Learning Machines –3rd Edition- Pearson Prentice Hall-ISBN-13: 978-0131471399.* 5. *Guanrong Chen "Introduction to Fuzzy Sets,Fuzzy logic and Fuzzy control System" Trung Tat Pham-CRC Press -ISBN 0-8493-1658-8*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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		2. Mr.Jesu Godwin D, SRMIST

Course Code	18AUE314T	Course Name	CAD AND SIMULATION FOR ELECTRONICS	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 concepts of modeling in 2D and 3D.*
CLR-2 :	*Gain knowledge on computer graphics and Simulation.*
CLR-3 :	*Understand CAD Packages for electronics and recent technologies.*
CLR-4 :	*Use concepts of Computer Graphics in Printed Circuit Boards and Packaging*
CLR-5 :	*Use relevant CAD Standards for Circuit Simulation*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Use and Relate the role of CAD in Electronics and board design.*	*1*	*90*	*85*
CLO-2 :	*Understand the basic Math fundamentals behind CAD software Graphics.*	*2*	*90*	*85*
CLO-3 :	*Design and Execute Circuits Boards Simulations*	*2*	*85*	*80*
CLO-4 :	*Design Models for Electronic Packaging using CAD*	*2*	*85*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
H	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*L*	*L*	*M*
H	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*M*	*L*	*M*	*M*	*H*	*M*
H	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*

Duration (hour)		Introduction	Graphics Concepts and Algorithms	Analog Circuit simulation	CAD for Circuit and Component Analysis	CAD for Printed Circuits Boards and Packaging
		9	9	9	9	9
S-1	SLO-1	*Introduction to Design process – CAD*	*Introduction to computer Graphics*	*Introduction to simulation*	*Introduction to Circuits*	*Components of a CAD package and its highlights.*
	SLO-2	*Steps and design Process*	*Interactive graphics display*	*Purpose Of Simulation*	*DC Steady State analysis*	*Circuit design with CAD package.*
S-2	SLO-1	*Geometric Modeling Introduction*	*Display devices, Pixels*	*Simulation Examples*	*Simulation Example :Voltage regulator*	*Work layout and component layout*
	SLO-2	*Parametric Representation of Lines and curves*	*Algorithms in computer Graphics*	*Circuit Equation Modulation*	*AC Analysis*	*Process flow-chart.*
S-3	SLO-1	*Parametric Representation of synthetic curves*	*DDA Line Drawing Algorithms*	*Simulation of Modified Nodal analysis method*	*Simulation Example : Cascode amplifiers with Macro Models*	*Printing technologies for Printed Wiring Boards*
	SLO-2	*Geometric Modeling: Entities - Line - Circle - Ellipse - Parabola*	*Bresenham's Line Drawing algorithm*	*Modified Nodal analysis.*	*Cascode amplifiers with Macro Models*	*Semiconductor Packaging Overview*
S-4	SLO-1	*Geometric Modeling: Types – Wireframe modeling.*	*Bresenham's Circle Drawing algorithm*	*Active device Models overview*	*Simulation example : Transient analysis Phase Locked Loop circuit*	*Semiconductor Packages*
	SLO-2	*Geometric Modeling: Types - surface and solid modeling.*	*Point clipping algorithms*	*DC Circuit Simulation Overview*	*Process and device simulation Overview*	*Semiconductor Packages design case study*
S-5	SLO-1	*Solid modeling techniques Overview*	*Cohen Sutherland Line clipping algorithms*	*Newton's Method on DC analysis*	*Process simulation, diffusion, Oxidation, Ion implantation*	*Board-level packaging aspects*
	SLO-2	*Constructive Solid Geometry – Boolean set Operations, Sweep Representation*	*Hidden line removal algorithms*	*AC Circuit Simulation Overview*	*Simulation Example: NMOS Transistor*	*Board-level packaging aspects.*
S-6	SLO-1	*Constructive Solid Geometry – Quad tree Structure.*	*2D and 3D transformations*	*AC Circuit Simulation Example Program*	*Device simulation*	*Packaging Examples Case study*
	SLO-2	*Constructive Solid Geometry- Octree structure*	*Translation, rotation*	*Noise Simulation*	*NMOS IV Curves*	*CAD output files for PCB fabrication*

Duration (hour)		Introduction	Graphics Concepts and Algorithms	Analog Circuit simulation	CAD for Circuit and Component Analysis	CAD for Printed Circuits Boards and Packaging
		9	9	9	9	9
S-7	SLO-1	*Boundary Representation*	*Scaling – Concatenation.*	*Noise Simulation Example Program*	*Parameters Extraction for analog circuit simulation Overview*	*CAD output files Slandered file format*
	SLO-2	*Feature Based Modelling and Constraint Based Modelling*	*Homogeneous Transformation*	*Transient system Simulation*	*Device Characterization*	*Photo plotting and mask generation.*
S-8	SLO-1	*Parametric Modelling, Extrude, Sweep, Revolve*	*Translation and scaling*	*Verilog-A Overview*	*Least squares curve fitting*	*Photo Mask File Generation.*
	SLO-2	*Parametric Modelling Tools Cont*	*Refection and rotation*	*Verilog-A Example Program*	*Extraction and Optimization*	*Introduction to DFM, DFR , DFT*
S-9	SLO-1	*Feature Manipulation*	*Shear Transformation*	*Fast Simulation Methods*	*MOS DC models*	*DFM, DFR , DFT.*
	SLO-2	*CAD in Assembly and Drafting*	*Concatenated transformation - Inverse transformation*	*General Simulators Overview*	*MOS DC models.*	*Computer-Aided Analysis Application*

Learning Resources	
1. *Ibrahim Zeid, "CAD / CAM - Theory and Practice"., Tata Mcgraw-Hill, New Delhi, 2001* 2. *Newman and Sproull R. F., "Principles of interactive computer graphics", Tata Mcgraw-Hill, New Delhi,1997*	3. *Mikell P. Groover, "CAD / CAM"., Prentice Hall of India Private Limited, New Delhi, 1997* 4. *The Circuits and Filters Handbook Third Edition "Computer Aided Design Automation" Edited By Wai-Kai Chen*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Understand										
Level 2	Apply	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
	Analyze										
Level 3	Evaluate	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com*	*1. Mr. Joshua Paul E, SRMIST*
2. Jonny N, BGR Energy systems, jonnynallathampi@gmail.com		*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE316J	Course Name	AUTOMOTIVE MICROCONTROLLERS	Course Categzory	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*18AEE211J*	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 the knowledge of 8051 Microcontroller architecture*
CLR-2 :	*Program 8051 using Assembly level programming*
CLR-3 :	*Use the high level programming language for embedded application development*
CLR-4 :	*Get familiarized with the internals of AVR and program it using C language.*
CLR-5 :	*Learn about the special on-chip peripherals available on automotive grade Microcontrollers.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Perform the basic Operations of 8051 Microcontroller*	*2*	*85*	*75*	*H*	*M*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Carry out basic Operations of 8051 Microcontroller.*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Apply Embedded C Programming in Microcontroller.*	*2*	*90*	*85*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Program ATMEGA328 Microcontroller using Embedded C*	*2*	*85*	*80*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Identify and relate the various Microcontroller in automotive subsistence*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		8051 Architecture	Programming 8051	Introduction to Embedded C	Advanced Virtual Risc (AVR) Microcontrollers	Automotive Grade Processors
		12	12	12	12	12
S-1	SLO-1	*Introduction to Microprocessors and Microcontrollers and differences*	*Logical Operations-Bit level, Byte Level*	*Program Languages for Embedded system application*	*Introduction to ATMEGA328*	*Introduction to Automotive grade processors*
	SLO-2	*8051 Pin diagram and description*	*Internal RAM Bit address and SFR Bit address*	*Introduction to Higher level programming language*	*ATMEGA328 –Basic Features*	*Automotive grade processors ex: Renesas, Quorivva*
S-2	SLO-1	*8051 internal Architecture*	*Logical Operations-Rotate and swap Operation*	*Advantages of Higher level programming language*	*ATMEGA328 – Core SFR'S and Ports*	*Automotive grade processors : NXP, Infineon*
	SLO-2	*Clock, PC, DP, CPU registers,*	*Arithmetic Operations Incrementing, Decrementing*	*Basics of C program language – Data Types, variables*	*ATMEGA 328-Timer TMR0,TMR1,TMR2*	*Architectural attributes of Automotive grade processors Based on subsystems*
S 3-4	SLO-1	*Lab 1: 8051- Assembly level programming – Basic Arithmetic and logical operations*	*Lab 3: Introduction to Embedded C Programming and IDE-Tool chains - AVR-ATMEGA328 Operation on bits Blinking with Digital Outputs –Delay functions*	*Lab 5: ATMEGA328- Configuring on-chip ADC –Interfacing sensors*	*Lab 7: ATMEGA328- Programming Serial Communication with Interrupts Type1,Type 2*	*Lab 9: Implementing a moving average filter for sensor noise correction*
	SLO-2					
S-5	SLO-1	*Data memory Organization*	*Arithmetic Operations : Addition, Subtraction*	*Keywords, Pointers ,Declarations, Constants and Operators*	*ATMEGA 328-Capture Compare Module-*	*On-chip Peripherals overview*
	SLO-2	*PSW, RAM, ROM, SP, SFR*	*Jumps, Calls and Subroutines*	*Introduction to Datatype conversions*	*ATMEGA 328-CCM in PWM Mode*	*Special On-chip Peripherals for Body and chassis control applications*
S-6	SLO-1	*IO ports, Connecting External Memory, Counters, Timers*	*Interrupts and Return*	*Switch case and If Loop,For Loop and While Loop*	*ATMEGA 328-Interrupts Type1,Type 2*	*On-chip Peripherals for Engine and Power train control*
	SLO-2	*Serial Data Input / output, Interrupts*	*Expanding I/O overview*	*Arrays and pointers*	*ATMEGA 328- Interrupt Model, Interrupts vectors*	*Overview of Automotive communication protocols : CAN, LIN*

Duration (hour)		8051 Architecture	Programming 8051	Introduction to Embedded C	Advanced Virtual Risc (AVR) Microcontrollers	Automotive Grade Processors
		12	12	12	12	12
S 7-8	SLO-1	*Lab 2: 8051-Finding 2's complement of a number*	*Lab 4:ATMEGA328 –EEPROM Programming*	*Lab 6: ATMEGA328-Programming Interrupts and Timers*	*Lab 8: ATMEGA328-Working with RTC and I2C*	*Lab 10:Building an Automotive Embedded application with ATMEGA328*
	SLO-2					
S-11	SLO-1	*Addressing Modes of 8051 Microcontroller Overview*	*Memory Mapped I/O*	*Functions and Structure*	*ATMEGA 328-Serial Communication Modules-I2C,SPI*	*Automotive communication protocols : Flex Ray, MOST*
	SLO-2	*Immediate and Register Addressing ModesDirect and Register indirect Addressing modes of 8051 Microcontroller*	*Timing Subroutine-Software and Hardware Delay*	*Embedded Programming Tool ,IDE with Simulator*	*ATMEGA 328-Serial Communication Basic Programs*	*Automotive communication protocols : Ethernet,D2B and DSI*
S-10	SLO-1	*External memory access of 8051 Microcontroller*	*Lookup table for 8051 PC,DPTR as Base address*	*Embedded C Compilers*	*Analog Modules –A/D converter,Comparator*	*Introduction to Real-time operating system – for task scheduling activities*
	SLO-2	*Timer and counter of 8051 Microcontroller*	*Serial Data Transmission-Polling and interrupt driven for transmission and reception*	*Data types and libraries in Embedded C*	*Clock Oscillator ,EEPROM*	*RTOS Classification - Hard Real-time and Soft Real time*
S 11-12	SLO-1	*Lab: Assessment 1*	*Lab: Assessment 2*	*Lab: Assessment 3*	*Lab: Review class*	*Lab: Mini Project*
	SLO-2					

Learning Resources	1. *Kenneth.J.Ayala "The 8051 Microcontroller,Architecture,Programming and Application" West Publishing Company,1991* 2. *Muhammad Ali Mazidi, SarmadNaimi, SepehrNaimi "AVR Microcontroller and Embedded Systems Using Assembly and C "Pearson Custom Electronics Technology, 2011.*	3. *Muhammad Ali Mazidi, Janice Mazidi, Janice Gillispie Mazidi-8051 Microcontroller and Embedded Systems, The (1999)* 4. *Gilbert Held "Inter and Intra Vehicle Communications: Auerbach Publications,2008* 5. *DataSheets of Kinetis 32-bit MCU based on ARM,InfineonXCxx series and Multicore Aurix Architecture*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20 %*	*20 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Understand										
Level 2	Apply	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*
	Analyze										
Level 3	Evaluate	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT <a.jegan@kpit.com>	*1. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*1. Mr. D. Jesu Godwin, SRMIST*
		2. Mr. E. Joshua Paul, SRMIST

Course Code	18AUE317J	Course Name	AUTOMOTIVE CONTROL ENGINEERING	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 :	*Familiarize about the importance of feedback control in automotive applications*
CLR-2 :	*Understand the status of the system in terms of stability*
CLR-3 :	*Develop the knowledge of controller and compensator design*
CLR-4 :	*Familiarize and execute stability analysis on linear system*
CLR-5 :	*Understand the concept of frequency response and analyze feedback systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Find the transfer function for linear control systems .*	*2*	*85*	*75*	*H*	*M*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Perform time response analysis for standard prototyping systems.*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Perform stability analysis for the system under study*	*2*	*90*	*85*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Apply frequency analysis for the system under study*	*2*	*85*	*80*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Design and implement controllers and compensators for the system under study*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		Introduction to Feedback Systems	Performance of Feedback Systems	Stability Analysis of Linear System	Frequency Response Analysis of Feedback Systems	Controller Design for Linear Feedback System
		12	12	12	12	12
S-1	SLO-1	*Introduction to Systems and its types*	*Introduction to time response analysis*	*Introduction to the Concept of Stability*	*Introduction to Frequency response*	*Introduction to controllers P,PI,PD,PID*
	SLO-2	*Examples of automotive feedback systems*	*Transient response and steady state response*	*Bounded-input, Bounded-output stability(BIBO)*	*Sinusoidal excitation and response to a system*	*Effect of Proportional, Integral and differentiator constants*
S-2	SLO-1	*ADAS, Engine Management system*	*Sensitivity of a feedback system*	*Routh –Hurwitz stability criterion*	*Introduction to Frequency response plots and performance specification*	*PID design for an automotive feedback system*
	SLO-2	*Linear Time invariant systems*	*Standard test inputs for feedback system analysis*	*Routh –Hurwitz stability - Basic Numerical Problems*	*Bode plot - constant gain*	*Frequency domain interpretation of PID controller*
S 3-4	SLO-1	*Lab 1:Introduction To Matlab Control System Tool Box, Simulink Tool Box*	*Lab 3: Simulation of cruise control example using Matlab Simulink*	*Lab 5: Stability analysis of Second Order UnityFeedback System using Matlab control system toolbox.*	*Lab 7: Determination Of Bode Plot Using Matlab Control System Toolbox for 2nd Order System & Obtain Controller Specification Parameters.*	*Lab 9: Implementantion of Proportional-Integral-Derivative (PID) controller using Matlab Control System Toolbox.*
	SLO-2					
S-5	SLO-1	*Parameter varying system and Nonlinear system*	*Transient response and steady state response - Numerical Problems*	*Routh – Hurwitz stability - Basic Numerical Problems Cont.*	*Bode plot - differentiator ,integrator and second order term*	*Frequency domain interpretation of PID controller*
	SLO-2	*Impulse response of a system and transfer function representation*	*Time response analysis of a first order prototyping system*	*Routh – Hurwitz stability in controller parameter selection*	*Phase Margin and Gain Margin fundamentals*	*PID Numerical Problems*
S-6	SLO-1	*Transfer function of a D.C motor*	*Time response analysis of First order prototyping system - Numerical Problems*	*Stability analysis of tracked vehicle turning control*	*Procedure to plot bode diagram – Gain margin,Phase margin and stability conditions*	*Lead compensator,Lag compensator*
	SLO-2	*Transfer function of Throttle position sensor, Velocity Sensor,Accelerometer Model*	*Time response analysis - Cruise control model*	*Stability analysis of tracked vehicle turning control Cont.*	*Bode Diagram - Numerical Problems*	*Lead Lag compensators Numerical Examples*

Duration (hour)		Introduction to Feedback Systems	Performance of Feedback Systems	Stability Analysis of Linear System	Frequency Response Analysis of Feedback Systems	Controller Design for Linear Feedback System
		12	12	12	12	12
S 7-8	SLO-1	*Lab 1: Transfer Function - DC Motor Speed control Simulink Modeling,*	*Lab 4:Simulation of suspension system System in Matlab Simulink*	*Lab 6: Determination Of Root Locus Plot And Controller Specifications Using Matlab Control SystemToolbox*	*Lab 8: Determination Of Nyquist Plot Using Matlab Control System Toolbox.*	*Lab 10: Designing Compensators using Matlab Simulink*
	SLO-2					
S-9	SLO-1	*Introduction to Block diagram algebra*	*Time response analysis of second order prototyping system*	*The Root locus procedure for stability analysis*	*.Polar Plot - Overview*	*Design of phase lead and phase lag compensation*
	SLO-2	*Block diagram algebra Numerical examples*	*Time response analysis of second order prototyping system - Numerical Problems*	*Root locus Analysis - Basic Problems*	*.Polar Plot - Numerical Problems*	*Time domain and frequency domain interpretation of design of phase lead and phase lag compensation*
S-10	SLO-1	*Introduction to Signal Flow Graph*	*Complex Plane root location and transient response*	*Root locus Analysis of speed control system*	*Nyquistcriterin for non-minimum phase system*	*Notch Filter*
	SLO-2	*Signal Flow Graph numerical problems*	*Steady state error of feedback control system - Numerical Problems*	*Controller design using root locus for a closed loop control system-Numerical Example*	*Nyquistcriterin for non-minimum phase system*	*Notch Filter Numerical Problems*
S 11-12	SLO-1	*Lab: Assessment 1*	*Lab: Assessment 2*	*Lab: Assessment 3*	*Lab: Review class*	*Lab: Mini Project*
	SLO-2					

Learning Resources		
1. *Richard.C.Dorf and Robert.H.Bishop, "Modern Control System" 12th edition Pearson Prentice Hall, 2013.* 2. *Benjamin.C.Kuo, "Automatic control systems", Prentice Hall of India, 7th Edition,1995*		3. *P N J.Nagrath and M.Gopal, "Control System Engineering", New Age International Publishers, 5th Edition, 2007.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Dr. Teoh Yew Heng, University Sains, Malaysia,yewhengteoh@usm.my*	*1. Mr.Jesu Godwin D, SRMIST*
	2. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in	*2. Mr. E. Joshua Paul, SRM IST*

Course Code	18AUE411T	Course Name	POWER ELECTRONICS FOR ELECTRIC VEHICLE APPLICATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AEE211J*	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 Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*List and recognize the various power semiconductor devices suitable for motor drive applications*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Identify and solve the DC-DC and AC-AC converters suitable for the desired requirements*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-3 :	*Experiment and sketch the various AC-DC Rectifier configurations and their input and output Waveforms*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Relate and use the DC - AC Inverters with various sources and control techniques*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-5 :	*Investigate and select the various motor drives suitable for the desired applications*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		Automotive Semiconductor Devices	AC -DC Converters	AC-DC Rectifiers	DC - AC Inverters	Automotive Motor Drives
		09	09	09	09	09
S-1	SLO-1	*Introduction to power semiconductor devices*	*DC-DC Converter - Basics*	*Half Bridge Diode AC-DC Rectifier*	*DC-to-AC Conversion- Basics*	*DC motor drives-introduction*
	SLO-2	*Diodes - Rectification*	*DC-DC Converter - Types*	*Characteristics and Circuit Configuration*	*DC-to-AC Conversion- Basics.*	*DC motor drives-Types*
S-2	SLO-1	*Diodes – Freewheeling*	*Buck, Boost, and Buck-Boost Converter overview*	*Full Bridge Diode AC-DC Rectifier*	*Introduction to Inverters*	*Torque Production in Brushed DC-Motor Drives*
	SLO-2	*Diodes - Clamping Devices*	*Buck, Boost, and Buck-Boost Converter Circuit overview*	*Characteristics and Circuit Configuration*	*Types of Inverters overview*	*Torque Production in Brushed DC-Motor Drives.*
S-3	SLO-1	*Power MOSFETs - Characteristics*	*Buck Converter - Components*	*Three-Phase Full-Bridge Diode Rectifier - Circuit Configuration*	*Voltage Source Inverters-Single phase inverters*	*Series connected DC motor drives*
	SLO-2	*Power MOSFETs - Low-Voltage Load Drivers*	*Buck Converter - circuit*	*Three-Phase Full-Bridge Diode Rectifier - Analysis*	*Voltage Source Inverters-Single phase Inverters applications*	*Series connected DC motor drives.*
S-4	SLO-1	*IGBTs - Characteristics*	*Buck Converter - Analysis*	*Three-Phase Full-Bridge Diode Rectifier - Waveforms*	*Voltage Source Inverters -Three phase Inverters`*	*Induction Motor Drives -Introduction*
	SLO-2	*IGBTs - High-Voltage Power Switches*	*Buck Converter*	*Design of Dynamic Breaking Unit*	*Voltage Source Inverters -Three phase Inverters applications*	*Induction Motor Drives.*
S-5	SLO-1	*Power Integrated Circuits*	*Boost Converter - Components*	*Design of Dynamic Breaking Unit.*	*Current Source inverters*	*Induction motor Variable Speed Drive operating modes*
	SLO-2	*Power Integrated Circuits Examples*	*Boost Converter - Circuit*	*Calculation of DC-Link Power*	*Current Source inverters applications*	*Induction motor Variable Speed Drive operating modes.*
S-6	SLO-1	*Smart Power Devices*	*Boost Converter - Analysis*	*Calculation of DC-Link Power*	*Voltage Control Techniques – Sinusoidal PWM (SPWM) Technique*	*Torque and speed control of Induction - Motor Drives*
	SLO-2	*Smart Power Devices.*	*Boost Converter - Analysis.*	*Three-Phase Full-Bridge. Thyristor AC-DC Rectifier-Circuit Configuration*	*Voltage Control Techniques – Sinusoidal PWM (SPWM) Techniques.*	*Torque and speed control of Induction - Motor Drives.*

Duration (hour)		Automotive Semiconductor Devices	AC -DC Converters	AC-DC Rectifiers	DC - AC Inverters	Automotive Motor Drives
		09	09	09	09	09
S-7	SLO-1	*Emerging Device Technologies - Super-Junction*	*Buck-Boost Converter - Components*	*Three-Phase Full-Bridge Thyristor AC-DC Rectifier-Analysis*	*Current control techniques - HysteresisCurrent Control*	*Fundamentals of Scalar and vector control for induction motors*
	SLO-2	*Emerging Device Technologies - Super-Junction.*	*Buck-Boost Converter - Circuit*	*Three-Phase Full-Bridge Thyristor AC-DC Rectifier-Waveforms*	*Current control techniques – Hysteresis Current Control*	*Types of scalar control for induction motors*
S-8	SLO-1	*Emerging Device Technologies - SiC Devices*	*Buck-Boost Converter - Analysis*	*Topology and Operation Modes*	*Multilevel inverters*	*Vector control for induction motors.*
	SLO-2	*Emerging Device Technologies - SiC Devices.*	*Push-Pull Converter - Half Bridge*	*Topology and Operation Modes.*	*Multilevel inverters.*	*Types of vector control for induction motors.*
S-9	SLO-1	*Power Losses in semiconductors*	*Push-Pull Converter - Full Bridge*	*Fire Angle Control Scheme*	*Hard Switching Effects*	*Induction motor drives for Electric Vehicles*
	SLO-2	*Thermal Management in semiconductors*	*AC- AC Converters*	*Fire Angle Control Scheme.*	*Hard Switching Effects. .*	*Induction motor drives for Electric Vehicles.*

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, 3rd Edition, New Delhi, 2004*

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a..jegan@kpit.com	*1. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*1. Mr. Srividya K, SRMIST*
		2. Mr.Jesu Godwin D, SRMIST

Course Code	18AUE412T	Course Name	STATE SPACE ANALYSIS AND DIGITAL CONTROL SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*18AEE317J*	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 basics of discrete systems and digital control*
CLR-2 :	*Design and implement digital controllers for discrete time models*
CLR-3 :	*Formulate state space models for dynamics system*
CLR-4 :	*Acquire the fundamentals of pole placement design and state observers*
CLR-5 :	*Explore the techniques involved in optimal control design*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*List and recognize the various discrete systems and digital control*	*1*	*90*	*85*
CLO-2 :	*Identify and solve the various digital controllers for discrete time models*	*2*	*90*	*85*
CLO-3 :	*Experiment on the various state space models for dynamics systems*	*2*	*85*	*80*
CLO-4 :	*Relate and use the pole placement design and state observers*	*2*	*85*	*80*
CLO-5 :	*Investigate and implement the optimal control design*	*3*	*85*	*80*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
H	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
H	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		Signal Processing in Digital Control	Models of Digital Control Systems and Algorithm	Control System Analysis With State Variable Methods	Pole Placement Design and State Observers	Lyapunov Stability Analysis and Optimal Control
		09	09	09	09	09
S-1	SLO-1	*Introduction Signal Processing*	*Introduction to Z transform*	*Introduction to state space analysis*	*State feedback Overview*	*Basic stability definitions*
	SLO-2	*Control system terminologies*	*Z domain specification*	*State variable representation of system*	*Stability improvement by state feedback*	*Theorems on stability*
S-2	SLO-1	*Classical approach to analog controller design*	*Z-domain description of sampled continuous time plant*	*State variable representation.*	*Introduction to Pole Placement*	*Sign definiteness of functions and matrices*
	SLO-2	*Classical approach to analog controller design. Cont*	*Z-domain description of sampled continuous time plant. Cont*	*State space analysis of systems overview*	*Necessary and sufficient conditions for arbitrary pole-placement*	*Lyapunov Stability Theorems for linear and nonlinear systems*
S-3	SLO-1	*Introduction to digital control system*	*Implementation of Digital controllers*	*State space analysis of systems. Cont*	*Voltage Source Inverters-Single phase inverters*	*Lyapunov's first or indirect method*
	SLO-2	*Configuration of basic digital control system scheme*	*PI,PD,PID controllers*	*Conversion of transfer function to state variable model*	*State regulator design*	*Lyapunov's second or direct method*
S-4	SLO-1	*Basic discrete time signals*	*Tunable PID controller*	*Transfer function to state variable model numerical Examples*	*State regulator design.*	*Lyapunov function candidate and Matrix Equation*
	SLO-2	*Time domain models of discrete time system*	*Tunable PID Speed Control problem*	*Transfer function to state variable model numerical Examples. Cont*	*State observers*	*Parameter Optimization*
S-5	SLO-1	*Transfer function Overview*	*Conversion of Canonical state variable to transfer function model*	*Conversion of Canonical state variable to transfer function model*	*Design of state observers*	*Optimal control examples*
	SLO-2	*Transfer function Models*	*Digital temperature control*	*Conversion of Canonical state variable to transfer function model Numerical Examples*	*State observers for linear systems*	*Performance indices*
S-6	SLO-1	*Transfer function Models.*	*Concepts of controllability*	*State observers for linear systems*	*State observers for non- linear systems*	*Quadratic Performance index*
	SLO-2	*Introduction to Stability analysis*	*Z-plane specification for control system design*	*State observers for linear systems Examples*	*State observers examples.*	*Quadratic Performance index example*

Duration (hour)		Signal Processing in Digital Control	Models of Digital Control Systems and Algorithm	Control System Analysis With State Variable Methods	Pole Placement Design and State Observers	Lyapunov Stability Analysis and Optimal Control
		09	09	09	09	09
S-7	SLO-1	*Stability on z-plane and the Jury stability criterion*	*Z-plane specification for control system design.*	*Concept of observability Numerical examples*	*Digital control system with state feedback*	*Performance indices examples*
	SLO-2	*Sampling as impulse Modulation*	*Introduction to digital compensator*	*State feedback with integral control*	*State feedback with integral control*	*Quadratic Performance index example State regulator design*
S-8	SLO-1	*Practical aspects on the choice of sampling rate*	*Digital compensator design using frequency response*	*Multivariable control system overview.*	*Dead beat control concept*	*State regulator design through Lyapunov equation*
	SLO-2	*Principles of Discretization*	*Digital compensator design using frequency response.*	*Multivariable control system Numerical Examples*	*Multilevel inverters.*	*Duality and Observability*
S-9	SLO-1	*Routh Stability criterion*	*Digital compensator design using root locus plots*	*Digital state space Models*	*Dead beat control by state feedback and Dead beat observers*	*Optimal state regulator through the matrix riccati equation*
	SLO-2	*Routh Stability criterion-.*	*Digital compensator design using root locus plots.*	*Digital state space Models Examples*	*System identification and adaptive control*	*Optimal digital control systems*

Learning Resources	1. *M G opal "Digital Control and State Variable Methods", 4th edition, Tata McGraw Hill Education Pvt.Ltd. 2012* 2. *Kats uhiko Ogata "Discrete time control system" 2nd edition ,Prentice Hall Pvt.Ltd,2012* 3. *J.Nagrath and M.Gopal, "Control System Engineering", New Age International publishers, 5th Edition, 2007.*	2. *Richard.C.Dorf and Robert.H.Bishop, "Modern Control System" 12th edition Pearson Prentice Hall, 2013.* 3. *Benjamin.C.Kuo, "Automatic control systems", Prentice Hall of India, 7th Edition,1995.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
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1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*1. Mr.Jesu Godwin D, SRMIST*
	2. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com	*2. Mr. E. Joshua Paul, SRMIST*

Course Code	18AUE413T	Course Name	MODEL BASED SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AEE317J*	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 concept of V-development approach in automotive controller design*
CLR-2 :	*Distinguish and demonstrate the different modelling techniques used in model based system design*
CLR-3 :	*Understand the architecture of ECU and Rapid prototyping Hardware*
CLR-4 :	*Understand the concept of real time simulation and HIL simulation*
CLR-5 :	*Create models of physical systems using design of experiment methods*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify and Build mathematical models for components in a system.*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Investigate on the continuous refinement and improvement to generate accurate models*	*2*	*90*	*85*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-3 :	*Experiment and run Hardware-in-the-Loop Simulations (HIL)*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Relate and apply basic control algorithms to a real physical system*	*2*	*85*	*80*	*H*	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*M*	*H*	*H*	*H*	*M*
CLO-5 :	*Apply verification and validation methods to a physical system model*	*3*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		Model Based Design Approach	Modelling Techniques and development	ECU Architecture and Design	Real-time Simulation	Model Based System Design Application
		09	09	09	09	09
S-1	SLO-1	*Introduction to design process*	*Introduction to graphical modelling*	*Rapid Prototyping hardware architecture and features*	*Introduction to real-time simulation*	*Introduction to model based system design software tools*
	SLO-2	*Design validation and verification and requirements*	*State Flow Modelling*	*Programming analog ,digital interface*	*Standalone Plant Simulation*	*Overview of Simulink and Sim driveline*
S-2	SLO-1	*Design process implementation*	*State machines Modelling*	*Protocol interface and implementing controller*	*Standalone Controller Simulation*	*Modelling a series hybrid electric vehicle in Sim drive line*
	SLO-2	*Introduction to model based design*	*Algorithmic models*	*ECU Design - Need for ECUs*	*Plant and controller simulation on single target*	*Modelling a series hybrid electric vehicle in Sim drive line.Cont*
S-3	SLO-1	*Model based design in functional level*	*Transfer function modelling*	*Advances in ECUs for automotive application*	*Plant and controller simulation on single target.Cont*	*Driver model in Simulink*
	SLO-2	*Model based design in Architecture level*	*State space modelling*	*Requirements for ECU design*	*RT simulation by Separating the plant from the controller*	*Battery model in Simulink*
S-4	SLO-1	*Model based design in implementation level*	*Event based Modelling*	*Design complexities of ECU*	*Real-time simulation.Cont*	*Modelling electric motor in Simulink*
	SLO-2	*Key barriers in adaptation of model based engineering*	*Statistical modelling for system identification*	*Selection of sensors for ECU design*	*Controller and Plant on real time target*	*Modelling speed tracking controller model in Simulink*
S-5	SLO-1	*Introduction to V-development cycle*	*Mathematical Modelling for automotive applications*	*Selection of interfaces for ECU design*	*Controller and Plant on real time target Cont.*	*Modelling of a single cylinder IC engine in powertrain block set*
	SLO-2	*V-developments cycle significance*	*Simple motor and generator model*	*Selection of actuators for ECU design*	*V and V using HIL RT Model*	*Modelling of a single cylinder IC engine in powertrain block set.Cont*
S-6	SLO-1	*V-development cycle in automotive domain*	*Simple IC engine model, Controller model*	*Selection of actuators for ECU design .Cont*	*V and V using HIL RT Model case study*	*Modeling of an IC engine controller in powertrain block set*
	SLO-2	*Rapid control prototyping*	*IC engine Controller model*	*ECU Hardware -Architecture of an advanced Microcontroller*	*Implementation of communication interfaces*	*Modeling of an IC engine controller in powertrain blockset.Cont*

Duration (hour)		Model Based Design Approach	Modelling Techniques and development	ECU Architecture and Design	Real-time Simulation	Model Based System Design Application
		09	09	09	09	09
S-7	SLO-1	*Model-in-loop simulation*	*Quarter car model*	*Overview of on chip peripherals*	*Verification of communication interfaces*	*Virtual modelling of electrified powertrains*
	SLO-2	*Software-in-loop simulation*	*Cruise control model*	*ECU on chip peripherals.Cont*	*A/D Outputs implementation*	*Virtual modelling of electrified powertrains.Cont*
S-8	SLO-1	*Hardware-in-loop simulation*	*Motor model and development.*	*ECU protocol interfaces*	*Control algorithm implementation*	*Development a hybrid vehicle model*
	SLO-2	*Processor in the loop simulation*	*Generator model Development.*	*GPIO on the advanced Microcontroller ECU*	*Timing requirements in control algorithm*	*Development a hybrid vehicle model. Cont*
S-9	SLO-1	*Vehicle in the loop simulation*	*Motor controller model and development.*	*Overview of ECU programming*	*Verification of timing requirements in control algorithm*	*Supervisory logic implementation of Hybrid vehicle.*
	SLO-2	*Constraints in HIL,MIL,SIL,PIL*	*Motor controller model and development. Cont*	*ECU interface challenges*	*Control algorithm optimization*	*HIL simulation of Hybrid vehicle.*

Learning Resources	
1. Pete r Wilson and H.AlanMantooth "Model based Engineering for complex Electronics system" 2013,Newness *2. Web course by Zachariah chambers and Marc Herniter –Rose Hulman institute of technology on "Introduction to model based design and Advanced model based design."*	*3. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, 3rd Edition, New Delhi, 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

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2. Jonny N, BGR Energy systems, jonnynallathampi@gmail.com	*2. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE414J	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	*18AEE317J*	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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 Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1:	*Compare and operate the different electric and hybrid vehicle power train configuration.*	*1,2*	*90*	*85*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*M*
CLO-2:	*Demonstrate and design the EV / HEV power train model and its components.*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3:	*Identify and examine the storage batteries, fuel cells and ultra capacitors used in vehicles.*	*1,2*	*85*	*80*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*H*	*M*
CLO-4:	*Construct and solve the EV / HEV power and energy management systems.*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*M*
CLO-5:	*Design the driver, vehicle, environmental model of EV/HEV dynamics control system*	*2,3*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*L*	*L*	*M*	*L*	*M*	*H*	*H*	*H*

Duration (hour)		*Introduction to Electric Vehicles*	Electric and Hybrid Power train Technologies	Modelling and Characteristics of EV/HEV Power train Components	Energy Storage	Energy, Power Management Systems And Techniques For EV and HEV
		12	12	12	12	12
S-1	SLO-1	*Introduction to Battery Electric Vehicles (BEV's) – Power train Configuration, Traction*	*Electric Motor Performance characteristics – Power and torque generation*	*Electro chemical batteries- Electro chemical reactions*	*Power /Energy management controllers*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Driver Model*
	SLO-2	*Introduction to Battery Electric Vehicles (BEV's) – Energy sources and storage*	*Electric Motor Performance characteristics – Efficiency, DC Motors*	*Electro chemical batteries- Electro chemical reactions*	*Power /Energy management controllers. Cont*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Driver Model*
S-2	SLO-1	*Fuel Cell Electric vehicle (FCEV) technologies*	*Electric Motor Performance characteristics – Induction AC motors, Steady state Performance analysis*	*Battery technologies – Lead acid battery*	*Battery Management system (BMS) for EV and HEV*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Vehicle Model.*
	SLO-2	*Fuel Cell Electric vehicle (FCEV) technologies*	*Electric Motor Performance characteristics – Permanent Magnet AC Motors ,BLDC motors*	*Battery technologies –Nickel based batteries*	*Battery Management system (BMS) for EV and HEV*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Vehicle Model*
S 3-4	SLO-1	*Lab 1: Introduction Lab*	*Lab 4: Data acquisition using data loggers and virtual instrumentation hardware*	*Lab 7: Testing and validation of Electric Vehicle Battery*	*Lab 10: Direction control of Electric Vehicle motors*	*Lab 13: Revision Lab*
	SLO-2					
S-5	SLO-1	*Hybrid Electric Vehicles- Degree of Hybridization, Parallel hybrid*	*Battery Performance Characteristics- Battery Capacity, Open circuit terminal voltages*	*Lithium based batteries –Lithium polymer*	*Rule based Control Strategies for HEV and PHEV –Deterministic Rule-based ,Fuzzy rule based control strategies*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Environment Model*
	SLO-2	*Hybrid Electric Vehicles-Series Hybrid*	*Battery Performance Characteristics-Charge and Discharge rates*	*Lithium based batteries –Lithium polymer*	*Rule based Control Strategies for HEV and PHEV –Deterministic Rule-based, Fuzzy rule based control strategies.*	*Fundamentals of Vehicle Dynamics Control (VDC) Systems –Environment Model.*
S-6	SLO-1	*Hybrid Electric Vehicles-Power split*	*Battery Performance Characteristics-SOC, SOD, DOD*	*Lithium based batteries –Lithium ion*	*Optimization based Control Strategies – Optimization Problem formulation*	*Working principle of VDC Systems*
	SLO-2	*Hybrid Electric Vehicles-compound Hybrid Configuration*	*Battery Performance Characteristics-Battery Energy Density, power density*	*Lithium based batteries –Lithium ion*	*Optimization based Control Strategies – Optimization Problem formulation.*	*Working principle of VDC Systems.*

Duration (hour)		*Introduction to Electric Vehicles*	Electric and Hybrid Power train Technologies	Modelling and Characteristics of EV/HEV Power train Components	Energy Storage	Energy, Power Management Systems And Techniques For EV and HEV
		12	12	12	12	12
S 7-8	SLO-1	*Lab 2: Introduction to Virtual Instrumentation and Rapid control prototyping hardware*	*Lab 5: Interfacing Analog input ,Signal conditioning using control hardware*	*Lab 8: Testing and Validation of Electric Motor for power assisted Steering system*	*Lab 11: Electronic differential Design for Electric Vehicles*	*Lab 14: Lab Model Examination*
	SLO-2					
S-9	SLO-1	*Plug-in Hybrid Electric Vehicles (PHEV's)*	*Battery Performance Characteristics-Specific energy and Specific Power*	*Ultra-capacitors –Basic principle, Performance, Ultra High speed flywheels*	*Global Energy/Power Management Optimization*	*VDC System Overview*
	SLO-2	*Hybrid Hydraulic vehicles (HHV)*	*Inverters and Motor drives*	*Ultra-capacitors –Basic principle, Performance, Ultra High speed flywheels*	*Real-time Energy/Power Management Optimization.*	*VDC implementation on Electric and Hybrid Vehicles-structure of the control system*
S-10	SLO-1	*Pneumatic Hybrid Vehicles (PHVs)*	*Inverters and Motor drives*	*Fuel cells –Principle, working , requirements and specifications*	*Optimization techniques*	*VDC implementation on Electric and Hybrid Vehicles-structure of the control system.*
	SLO-2	*Power/Energy Management System*	*Regenerative Braking Characteristics*	*Fuel cells –Principle, working , requirements and specifications*	*Optimization techniques*	*Control system Design and simulation study*
S 11-12	SLO-1	*Lab 3:Control prototyping using graphical programming methods Control prototyping using graphical programming methods*	*Lab 6: Control of actuators with Rapid control prototyping hardware*	*Lab 9: Speed control for Electric Vehicle motors*	*Lab 12: Revision*	*Lab 15: Evaluation & Discussion*
	SLO-2					

Learning Resources	1. *Amir Khajepour, M. Saber Fallah, AvestaGoodarzi-"Electric and Hybrid Vehicles Technologies, Modeling and Control" - A Mechatronic Approach-Wiley Publication,2014* 2. *Iqbal Husain, "Electric and Hybrid vehicles Design Fundamentals" , CRC Press,second edition 2013* 3. *James Larminie, John Lowry, "Electric vehicle technology Explained" secondEdition, Wiley Publication, 2012*	4. *Ali Emadi, MehrdadEhsani, John M. Muller,"Vehicular Electric Power Systems" Marcel Dekker, Inc., 2004* 5. *Electric vehicle Laboratory Manual* 6. *NI Systems "Compact Rio" Lab Manual*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*20 %*	*20 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Understand										
Level 2	Apply	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*	*20 %*
	Analyze										
Level 3	Evaluate	*10 %*	*10 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*	*15 %*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*1. Mr. Srividya K, SRMIST*
		2. Mr.Jesu Godwin D, SRMIST

Course Code	18AUE415T	Course Name	VEHICLE STABILITY AND CONTROL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18AEE317J*	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 concepts of vehicle stability and fundamentals of vehicle dynamics.*
CLR-2 :	*Design and Develop Vehicle, Road and driver models.*
CLR-3 :	*Understand Longitudinal and Lateral stability control schemes*
CLR-4 :	*Distinguish between the effects of Longitudinal and Lateral stability*
CLR-5 :	*Interpret the relation between vertical dynamics and ride stability control*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Use and Relate fundamental mathematical concepts to create a Vehicle Model*	*1,2*	*90*	*85*
CLO-2 :	*Identify and Optimize parameters like driver behavior and road quality as inputs to check vehicle stability*	*2,3*	*85*	*80*
CLO-3 :	*Recognize the effects of Longitudinal and Lateral stability*	*1,2*	*85*	*80*
CLO-4 :	*Design and check a vehicle for longitudinal and lateral stability*	*2,3*	*85*	*80*
CLO-5 :	*Create mathematical models of suspension behavior and control*	*2,3*	*85*	*80*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*L*	*L*	*M*
CLO-2 :	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*H*	*M*	*L*	*M*	*M*	*H*	*M*
CLO-3 :	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*
CLO-5 :	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*

Duration (hour)		Introduction to Vehicle Stability	Vehicle, Road and Driver Modeling	Longitudinal Dynamics and Control	Lateral Dynamics and Control	Vertical Dynamics and Control
		9	9	9	9	9
S-1	SLO-1	*Introduction to stability of motion*	*Introduction to Vehicle Modeling*	*Introduction to longitudinal control*	*Automated lane keeping*	*Introduction to Automotive Suspension*
	SLO-2	*Concept and analysis of stability in motion*	*Introduction to Vehicle Modeling*	*Adaptive Cruise Control*	*Steering control for automated lane keeping*	*Passive suspension*
S-2	SLO-1	*Static stability*	*Vehicle Modeling*	*Collision avoidance system*	*Lane keeping with Bicycle model*	*Quarter Car model – passive suspension*
	SLO-2	*Dynamic stability*	*Vehicle Modeling. Cont*	*Automated Highway systems*	*Lane keeping with Bicycle model - state feedback*	*Active suspension system*
S-3	SLO-1	*Mathematical forms for vehicle dynamic equations*	*Friction coefficient*	*Cruise controller design*	*Steady state error from dynamic equation*	*Tradeoffs and Limitation of Active suspension*
	SLO-2	*Mathematical forms for vehicle dynamic equations*	*Calculation of forces*	*PI Controller for first order plant*	*Steady state error from dynamic equation. Cont*	*Performance variable of quarter car suspension*
S-4	SLO-1	*Eigen values*	*Tire modelling*	*PI Controller for second order plant*	*Unity feedback loop system*	*Natural Frequencies for the Quarter Car*
	SLO-2	*Eigen values. Cont*	*Tire Characteristics*	*PID Cruise-controller design for second order actuator*	*Unity feedback loop system. Cont*	*Mode Shapes for the Quarter Car*
S-5	SLO-1	*Routh's stability*	*Effect of Wheel radius*	*Autonomous cruise control –Speed control*	*Loop analysis with a proportional controller*	*Approximate Transfer Functions Using Decoupling*
	SLO-2	*Routh's stability criterion. Cont*	*Effect of Wheel radius. Cont*	*Autonomous cruise control –Headway control*	*Loop analysis with a proportional controller. Cont*	*Approximate Transfer Functions Using Decoupling. Cont*
S-6	SLO-1	*Co-ordinates of vehicle dynamics model*	*Two track models*	*Adaptive cruise control –Cruise control with preview based on onsite information*	*Loop analysis with a lead compensator*	*Verification Using the Complete Quarter Model*
	SLO-2	*Notation of vehicle dynamics model*	*Reduced two track non-linear model*	*Adaptive cruise control –Cruise control with preview based on onsite information*	*Loop analysis with a lead compensator. Cont*	*Verification Using the Complete Quarter Model. Cont*
S-7	SLO-1	*Longitudinal vehicle motion –During acceleration*	*Road Model – Requirements of road model*	*Vehicle Platooning*	*Simulation of performance with Lead compensator*	*Optimal passive Suspension with 2DOF model*

Duration (hour)		Introduction to Vehicle Stability	Vehicle, Road and Driver Modeling	Longitudinal Dynamics and Control	Lateral Dynamics and Control	Vertical Dynamics and Control
		9	9	9	9	9
	SLO-2	*Longitudinal vehicle motion –During Braking*	*Course path of a Road Models*	*String stability*	*Simulation of performance with Lead compensator. Cont*	*Optimal active Suspension with 2DOF model. Cont*
S-8	SLO-1	*Vertical vehicle motion*	*Road surface quality*	*ACC –Autonomous control with constant spacing*	*Overview of four wheel steering*	*Linear Quadratic control*
	SLO-2	*One DOF quarter car model*	*Wind Strength - Effects*	*ACC –Autonomous control with constant time gap policy*	*Four wheel steering system numerical example*	*LQR Applications - active suspension*
S-9	SLO-1	*Lateral vehicle motion –Bicycle model*	*Human factors in driver automation*	*String stability of CTG spacing Policy*	*Yaw rate and acceleration response*	*LQR formulation for active suspension design*
	SLO-2	*Bicycle model in steady state cornering*	*Simple PID driver Model*	*String stability of CTG spacing Policy. Cont*	*Lane Change Maneuver – 2WS VS 4WS*	*LQR formulation for active suspension design. Cont*

Learning Resources		
	1. *Dean Karnopp "Vehicle Dynamics, Stability, and Control", 2nd edition, CRC Press, 2013* 2. *A.GalipUlsoy, HeuiPeng, Melih C "Automotive Control System", Cambridge University Press 2012*	3. *Rajesh Rajamani "Vehicle Dynamics and Control", Second Edition, Springer 2012* 4. *Kiencke U and Nielsen L "Automotive Control Systems for Engine, Driveline and Vehicle" 2nd edition, Springer 2005*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
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1. Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com	*1. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com*	*1. Mr. Dennie John, SRMIST*
2. Jonny N, BGR Energy systems, jonnynallathampi@gmail.com	*2. Mr. Arockiya Vijay, SRMIST, arockiaj1@srmist.edu.in*	*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE416T	Course Name	AUT0MOTIVE FAULT DIAGNOSTICS	Course Category	C	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the importance and procedure of fault diagnostics in for automotive field.*			
CLR-2 :	*Familiarize the fault diagnostics using tools and equipment*			
CLR-3 :	*Know about various case studies in fault diagnosis*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the concept of fault diagnosis*	*2*	*85*	*75*	*H*	*M*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-2 :	*Understand about on and off board diagnostics*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Perform fault diagnosis in automobiles*	*2*	*90*	*85*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-4 :	*Understand the various advances in fault diagnosis*	*2*	*85*	*80*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Perform electrical systems diagnosis in automobiles*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

Duration (hour)		Introduction Fault Diagnosis	On and off Board Diagnostics	Engine System Diagnosis	Chassis and Brake System Diagnosis	Electrical Systems Diagnosis
		9	9	9	9	9
S-1	SLO-1	*Introduction To Fault Diagnosis,*	*Introduction To ON and OFF Board Diagnostics*	*Introduction Engine Systems Diagnostics*	*Introduction To Engine System Diagnostics*	*Introduction to electrical components and Circuits*
	SLO-2	*Safe Working Practices And Techniques*				
S-2	SLO-1	*Diagnostics On Paper*	*Introduction To Oscilloscope Diagnostics*	*Engine Operation And Fuel System*	*Anti-Lock Braking System Diagnostics*	*Sensing, signal conditioning overview*
	SLO-2	*Systems And Standards*				
S-3	SLO-1	*Mechanical And Electrical Diagnostic*	*Sensors Associated With Oscilloscope Diagnostics*	*Ignition System And Emission System*	*Traction Control System Diagnostics*	*Multiplexing, Demultiplexing overview*
	SLO-2	*Techniques*				
S-4	SLO-1	*Faults Codes*	*Actuators Associated With Oscilloscope Diagnostics*	*Electronic Fuel Injection Diagnostics*	*Traction Control System Diagnostics - Steering*	*Lighting System Faults*
	SLO-2					
S-5	SLO-1	*On - And - Off Board Diagnostics*	*On-Board Diagnostics Various Perspectives*	*Starting And Charging System Diagnostics*	*Traction Control System Diagnostics - Tires*	*Auxiliary Faults*
	SLO-2					
S-6	SLO-1	*Data Sources*	*Petrol/Gasoline On-Board Diagnostics*	*Power Flow Control And Energy Efficiency Analysis*	*Transmission Systems Diagnostics*	*In-Car Entertainment Security And Communications Implementation*
	SLO-2	*Tools And Equipment's*				
S-7	SLO-1	*Oscilloscopes*	*On-Board Sensors*	*Engine Management And Faultfinding Information*	*Diagnostics On Steering*	*Body-Electrical Systems, Instruments System Faults*
	SLO-2	*Scanners/Fault Code Readers,*				
S-8	SLO-1	*Engine Analyzers*	*On-Board Actuators*	*Air Supply, Exhaust System Diagnostics*	*Diagnostics On Tires*	*Heating Ventilation And Air Conditioning electrical faults*
	SLO-2					
S-9	SLO-1	*Application Methods And Procedure*	*Sensors And Actuators Comparative Case Study*	*Cooling And Lubrication System*	*Case Study On Diagnostics Of Sub-Assemblies*	*Cruise Control, Air Bags Electrical faults*
	SLO-2					

Learning Resources	1. *Tom denton "Advanced automotive fault diagnosis", Elsevier butterworth-heinemannlinacre house, jordan hill, oxford ox2 8dp, uk - isbn-10: 0-75-066991-8* 2. *Tom Denton "Automotive Electronics Handbook", McGraw-Hill Publishing Co.; 2nd Revised edition 1999, ISBN10:0070344531*	3. *Routledge "Automobile Electrical and Electronic Systems", 4 edition 2012, ISBN10:0080969429* 4. *Newnes "Understanding Automotive Electronics", 6th Revised edition 2003,ISBN10:0750675993*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.G.Giri Atalon giri@atalon.co.in	*1. Dr. P. Sathish Kumar,Jiangsu University, China sathishkumar8989@gmail.com*	*1. Mr. S.Kiran, SRMIST*
2. Jonny N, BGR Energy systems, jonnynallathampi@gmail.com		*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE417T	Course Name	ELECTRONIC ENGINE MANAGEMENT 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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the components and operation of engine management systems.*			
CLR-2 :	*Learn about the various Engine sensors and actuators*			
CLR-3 :	*Learn about the various SI engine electronic ignition and injection systems*			
CLR-4 :	*Understand the various CI engine electronic ignition and injection systems*			
CLR-5 :	*Understand and study the engine emission control systems.*			
CLR-6 :	*Understand the concept of on board diagnostic systems and system data*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply knowledge on modern engine control strategies*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-2 :	*Analyze basic electrical and electronic devices and sensors, Ignition and Fuel Injection Systems involved in SI engine management*	*1*	*80*	*78*	*H*	*H*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-3 :	*Analyze basic electrical and electronic devices and sensors, Ignition and Fuel Injection Systems involved in CI engine management*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-4 :	*Understand the role of various actuators in engine management*	*2*	*85*	*80*	*H*	*L*	*H*	*H*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*L*
CLO-5 :	*Describe the key Computer controlled engine Systems*	*2*	*75*	*72*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*H*	*M*	*L*
CLO-6 :	*Access, and interpret on board diagnostic system information*	*2*	*75*	*73*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*H*	*M*	*L*

Duration (hour)		Fundamentals of Automotive Electronics and control	Sensors and Actuators	SI Engine Management	CI Engine Management	Digital Engine Control System
		9	9	9	9	9
S-1	SLO-1	*Introduction to Electronic Engine management System*	*Inductive, Hall Effect sensors*	*Layout and working of SI engine management systems*	*Introduction to CI engine management*	*Engine Mapping*
	SLO-2					
S-2	SLO-1	*Open and Closed loop control strategies*	*Thermistor, Piezo Electric sensors*	*Group and sequential injection techniques*	*Fuel injection system parameters affecting combustion*	*Effect of Air-fuel ratio/Spark timing/Exhaust gas Re circulation*
	SLO-2		*Piezo resistive based sensors*			
S-3	SLO-1	*Electronic Fuel Injection Systems*	*Throttle position, Mass air flow sensors*	*Contactless (Breaker less) Electronic ignition system*	*Noise in CI engines*	*knock control algorithm*
	SLO-2					
S-4	SLO-1	*Single-Point, Multi-Point Fuel Injection systems*	*Crank shaft position and Cam position sensors*	*Solid state ignition system*	*Emissions from CI engines*	*EGR Control algorithm*
	SLO-2					
S-5	SLO-1	*Electronic ignition systems*	*Engine Speed sensor, Knock Sensor*	*K - Jetronic, L - Jetronic fuel injection system*	*Electronically controlled Unit injection system*	*Integrated engine control system*
	SLO-2					
S-6	SLO-1	*Starter Motor working*	*Exhaust oxygen level sensor (two step, linear lambda and wide band)*	*Cold start and warm up phases, idle speed control*	*Common rail Diesel injection system*	*Electromagnetic compatibility*
	SLO-2	*Introduction to Engine control*				
S-7	SLO-1	*PI,PD,PID Control*	*Manifold temperature and pressure sensors*	*Acceleration and full load enrichment, Deceleration fuel cut off, Fuel control maps*	*Diesel injection system components Principle and working*	*EMI suppression techniques*
	SLO-2	*Look up tables*				
S-8	SLO-1	*Fuzzy logic control technique*	*Solenoid and stepper motor*	*Electronic spark timing and control, Spark advance ,Spark Retardation*	*Fuel pump, Fuel injector*	*On board diagnostics Tool*
	SLO-2	*Adaptive control techniques*				
S-9	SLO-1	*SI and CI Engine Control*	*Relay (four and five pin)*	*Closed loop control of knock*		

Duration (hour)		Fundamentals of Automotive Electronics and control	Sensors and Actuators	SI Engine Management	CI Engine Management	Digital Engine Control System
		9	9	9	9	9
	SLO-2	Combustion Performance and emission Parameters			*Rail pressure limiter, Flow meter, EGR valve*	*Trouble shooting on EMS and On board diagnostics system*

Learning Resources	1. *Understanding Automotive Electronics 8th Edition Authors: William Ribbens Paperback ISBN: 9780128104347 Imprint: Butterworth-Heinemann Published Date: 18th June 2017* 2. *Tom Denton "Automotive Electronics Handbook", - - McGraw-Hill Publishing Co.; 2nd Revised edition, 1999, ISBN10:0070344531*	3. *Diesel–Engine Management Hardcover – 20 Jan 2006 by Robert Bosch GmbH (Author), SAE Publications* 4. *Gasoline Engine Management (Bosch Professional Automotive Information) Paperback – 13 Aug 2014, SAE Publications* 5. *Automotive Fuel and Emissions Control Systems, 4th Edition James D. Halderman ©2016 |Pearson*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, and Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.Jegan Amirthalingam, Senior Educator, KPIT a.jegan@kpit.com*	*1. Dr, Teoh Yew Heng, University Sains, Malaysia, yewhengteoh@usm.my*	*1. Mr. S.Kiran, SRMIST*
2. *Mr.G.Giri Atalon giri@atalon.co.in*	*2. Mr. Sam Jebakumar, SRM IST, jebakumj@srmist.edu.in*	*2. Mr.Jesu Godwin D, SRMIST*

Course Code	18AUE455T	Course Name	MACHINE LEARNING APPROACH FOR AUTOMOTIVE APPLICATIONS	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:	Learning		
		1	2	3
		Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)
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 Learning Outcomes (CLO):	At the end of this course, learners will be able to:			
CLO-1 :	List and recognize the various machine techniques and condition monitoring techniques.	1	90	85
CLO-2 :	Identify and Estimate Parameters of signals using different sensors.	2	90	85
CLO-3 :	Identify and use various signal processing techniques.	2	85	80
CLO-4 :	Relate and use the various classification and regression models.	2	85	80
CLO-5 :	Investigationof condition monitoring for automotive application.	3	85	80

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem	Design & Development	Analysis, Design,	Modern Tool	Society &	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long	PSO - 1	PSO - 2	PSO – 3
H	M	M	M	L	L	L	L	M	M	L	M	H	M	M
H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
H	H	M	H	M	M	M	L	M	L	M	H	H	H	M
H	H	H	H	M	H	H	M	M	M	M	H	H	H	H

Duration (hour)		Introduction to Condition Monitoring	Instrumentation	Signal processing	Pattern Recognition	Application and case studies of condition monitoring
		09	09	09	09	09
S-1	SLO-1	Introduction to Machine Learning	Types of Sensors in Condition Monitoring and its Application	Basic Signal and Systems Concepts	Feature Extraction Methods	Application and Case Studies of Bearings
	SLO-2	Introduction to Condition Monitoring	Types of Sensors in Condition Monitoring and its Application	Basic Signal and Systems Concepts	Feature Selection Methods	Application and Case Studies of Bearings
S-2	SLO-1	Types of Machine Learning Techniques	Different Types of Vibration Sensors	Time Domain Analysis	Feature Reduction using PCA - Discriminant Functions	Case Study of Gearbox
	SLO-2	Supervised, Unsupervised And Reinforcement Learning	Working Principle of Piezoelectric Type Transducer	Time Domain Analysis	Feature Reduction using PCA - Decision Boundaries	Case Study of Gearbox
S-3	SLO-1	Machinery Failures	Different Types of Sound Sensors	Frequency Domain Analysis	Feature Reduction using Decision Tree	Case Study of Engines
	SLO-2	Basic Maintenance Strategies	Working Principle of Free Field Array Microphone	Frequency Domain Analysis	Feature Reduction using Decision Tree	Case Study of Engines
S-4	SLO-1	Factors Influencing Maintenance Strategies	Basic Principle of Acoustic Emission (AE) Signals	Time-Frequency Analysis	Classification using Maximum Likelihood and Nearest Neighbour	Structural Health Monitoring
	SLO-2	Factors Influencing Maintenance Strategies	Working Principle of AE Sensors	Time-Frequency Analysis	Bayesian Theory	Structural Health Monitoring
S-5	SLO-1	Machine Condition Monitoring	Types of Temperature Sensors and its Working Principle	Wavelets Analysis	Neural Networks	Machine Tool Condition Monitoring
	SLO-2	Machine Condition Monitoring	Types of Ultrasonic Sensors and its Working Principle	Wavelet Packets	Neural Networks	Machine Tool Condition Monitoring
S-6	SLO-1	Condition Based Maintenance Activity	Different Types of Infra-Red Sensors	Vibration Signatures of Faults in Rotating Machines	Fuzzy Logic	Machine Learning Vs Deep Learning

	SLO-2	*Condition Based Maintenance Activity*	*Working Principles of IR Sensor and its Key Application*	*Vibration Signatures of Faults in Rotating Machines*	*Fuzzy Logic*	*Machine Learning Vs Deep Learning*
S-7	SLO-1	*Transducer Selection and Location*	*Oil Analysis*	*Vibration Signatures of Faults in Reciprocating Machines*	*Support Vector Machines (SVM)*	*Machine Learning Vs Artificial Intelligence*
	SLO-2	*Transducer Selection and Location*	*Thermography*	*Vibration Signatures of Faults in Reciprocating Machines*	*Proximal Support Vector Machines (PSVM)*	*Machine Learning Vs Artificial Intelligence*
S-8	SLO-1	*PC Interfacing and Virtual Instrumentation*	*Motor Current Analysis*	*Detection and Diagnosis of Faults*	*Regression- Linear*	Machine Learning Applications Across Industries
	SLO-2	*PC Interfacing and Virtual Instrumentation*	*Motor Current Analysis*	*Detection and Diagnosis of Faults*	*Regression- Linear*	Machine Learning Applications Across Industries
S-9	SLO-1	*Data Driven Approach in Machine Learning*	*, Data Acquisition System (DAQ)*	*Classification and Regression*	*Regression- Polynomial*	*Tutorial*
	SLO-2	*Model Driven Approach in Machine Learning*	*Signal Conditioning*	*Classification and Regression*	*Regression- Polynomial*	*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*

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Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	*40%*	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.JeganAmirthalingam, Senior Educator, KPIT <a.jegan@kpit.com>*	*1. Dr. P. SathishKumar,Jiangsu University, China sathishkumar8989@gmail.com*	*1. Dr. T. Praveenkumar, SRMIST*
		2. Mr. E. Joshua Paul, SRMIST