ACADEMIC CURRICULA

Open Elective Courses

FACULTY OF ENGINEERING AND TECHNOLOGY

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	18AUO101T	Course Name	HYBRID AND ELECTRIC VEHICLES	Course Category	O	Open 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 an insight into how electric vehicle operate*
CLR-2 :	*Demonstrate the functional requirements of Battery management system in detail.*
CLR-3 :	*Demonstrate how Electric and Hybrid Vehicle vary as per design requirements.*
CLR-4 :	*Perform the detailed analysis on the drives and driveline.*
CLR-5 :	*Selection of the appropriate drive and driveline system 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 electric vehicle technology and electric vehicles.*	*2*	*90*	*85*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*M*	*M*	*H*	*H*	*H*	*M*
CLO-2 :	*Develop and analyze hybrid and electric drive trains.*	*2*	*90*	*80*	*H*	*H*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-3 :	*Interpret various vehicle power sources in hybrid vehicle technology*	*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 design calculations of hybrid system under study.*	*2*	*90*	*80*	*H*	*H*	*M*	*H*	*M*	*L*	*M*	*H*	*M*	*H*	*M*	*M*	*H*	*M*	*H*
CLO-5:	*Apply the concepts in sizing the electric motors*	*2*	*90*	*80*	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*M*

Title		Electric Vehicle Propulsion and Energy Sources	Electric Vehicle Powerplant And Drives	Hybrid and Electric Drivetrains	Electric and Hybrid Vehicle Design	Electric And Hybrid Vehicles – Case Studies
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts and problems concerning the electrification in Mobility*	*Basic concepts of electric vehicle power plant*	*Functional requirements of Hybrid Vehicle*	*Design perspectives of Hybrid vehicle*	*Parallel Hybrid, Series Hybrid -Charge Sustaining*
	SLO-2	*Functional components in an electric and hybrid vehicle*	*Power and Torque plot*		*Power plant energy distribution*	
S-2	SLO-1	*Vehicle Mechanics - Kinetics*	*Construction of Induction Machines,*	*Operational difference between the Fully Electric, Hybrid and Mild Hybrid*	*Matching the Electric Machine and the Internal Combustion Engine*	*Parallel Hybrid, Series Hybrid –Charge Depleting*
	SLO-2	*Vehicle Mechanics – Dynamics & Roadway Fundamentals*	*Operating cycle and application in traction*			
S-3	SLO-1	*Propulsion System Design - Force Velocity Characteristics,*	*Construction of Permanent Magnet Machines*	*Topological Phenomena and Social Importance of e-mobility*	*Parameter optimization – IC Engine*	*Hybrid Vehicle Case Study –Toyota Prius*
	SLO-2	*Calculation Of Tractive Power And Energy Required*	*Construction of Switch Reluctance Machines*		*Position and Types of arrangements*	
S-4	SLO-1	*Electric Vehicle Power Source - Battery Capacity*	*Role of Power Electronic Converters- DC/DC Converters*	*Role of modern drivetrain and the conversion efficiency and power consumption*	*Parameter optimization – Motor*	*Hybrid Vehicle Case Study –Honda Insight*
	SLO-2	*Battery Construction and Types*	*Description of Buck Boost Converter*		*Position and Types of arrangements*	
S-5	SLO-1	*State of Charge and Discharge*	*Isolated DC/DC Converter*	*Description of Hybrid Traction*	*Sizing of Propulsion Motor*	*Hybrid Vehicle Case Study –Chevrolet Volt*
	SLO-2		*Functional Requirements and Operating limits*		*Power Electronics & Drive System*	
S-6	SLO-1	*Calculation of Specific Energy and Specific Power & Ragone Plot Relationship*	*Two Quadrant Chopper*	*Description of Electric Traction.*	*Selection of Energy Storage Technology*	*42 V System for Traction Applications*
	SLO-2		*Switching Modes*		*Topological Optimization*	
S-7	SLO-1	*Battery Modeling - Run Time Battery Model, First Principle Model*	*AC Drives- PWM*	*Topological Optimization for Hybrid Traction*	*Communications & Supporting Subsystem*	*Lightly Hybridized Vehicles and Low Voltage System*
	SLO-2		*Current Control Method*	*Topological Optimization for Electric*		

				Traction		
S-8	SLO-1	*Battery Management System- SOC Measurement, Battery Cell Balancing.*	*Role of Switch Reluctance Machine Drives*	*Power Flow Control & Energy Efficiency Analysis*	*Energy Management Strategies in Hybrid Vehicles- Classification, Comparison, Implementation*	*Electric Vehicle Case Study - GM EV1, Nissan Leaf, Mitsubishi Miev*
	SLO-2			*Configuration and Control of DC Motor Drives*		
S-9	SLO-1	*Traction Batteries - Nickel Metal Hydride Battery, Li-Ion, Li-Polymer Battery.*	*Voltage Control*	*Induction Motor Drive.*	*Energy Management Strategies in Electric Vehicles- Classification, Comparison, Implementation*	*Hybrid Electric Heavy-Duty Vehicles, Fuel Cell Heavy Duty Vehicles*
	SLO-2		*Current Control*	*Permanent Magnet Motor Drives, Switch Reluctance Motor Drives, Drive System Efficiency.*		

Learning Resources	1. *Iqbal Husain, "Eclectic and Hybrid vehicles Design Fundamentals" , CRC Press, second edition 2013, ISBN 9781439811757* 2. *James Larminie, John Lowry, "Electric vehicle technology Explained" second Edition, Wiley 2012, ISBN-13: 978-1119942733*	3. *Ali Emadi, "Hand book of Automotive Power Electronics and Motor Drives", CRC Press 2005, ISBN 9780824723613.* 4. *Ali Emadi, Mehrdad Ehsani, John M. Muller,"Vehicular Electric Power Systems" Marcel Dekker, Inc., 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.K.V. Simmom, Royal Enfield, kvsimmon1@royalenfield.com	*1. Dr..A.Samuel Raja, Thiyagarajar college of Engineering Madurai, samuel1973@tce.edu*	*1. Mr. Kaviyarasu T, 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. Jerome Stanley M, SRMIST*

Course Code	18AUO102T	Course Name	RENEWABLE SOURCES OF ENERGY	Course Category	O	Open 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 :	*Explain the concept of wind energy*
CLR-2 :	*Create insight on solar energy and its application*
CLR-3 :	*Evaluate the use of geothermal and hydro power for power generation*
CLR-4 :	*Analyze the biomass energy and ocean energy*
CLR-5 :	*Develop knowledge on various energy conversion 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 :	*Apply the knowledge of using wind energy for power production*	*2*	*80*	*75*	*H*	*L*	*L*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*L*	*H*	*H*	*H*	*M*
CLO-2 :	*Analyze the economy of using solar power*	*2*	*85*	*80*	*H*	*L*	*L*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*L*	*H*	*H*	*H*	*M*
CLO-3 :	*Rationalize geothermal and hydro power plants*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*L*	*M*	*M*	*L*	*H*	*M*	*H*	*M*
CLO-4 :	*Perceive the concept of biomass and ocean energy for power production*	*2*	*80*	*75*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*L*	*H*	*M*	*M*	*L*
CLO-5 :	*Demonstrate the working of various energy conversion devices*	*2*	*85*	*80*	*H*	*L*	*M*	*M*	*M*	*H*	*H*	*L*	*L*	*M*	*L*	*H*	*M*	*M*	*L*

		Wind Energy	Solar Energy	Geo thermal and Hydro power	Ocean energy and Biomass based energy	Energy Conversions
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction- Renewable energy sources-statistics and technologies*	*Basic properties of solar energy*	*Geothermal – Resources, Types of wells*	*Ocean Energy – Principle, Utilization*	*Need for direct energy conversion (DEC), carnot cycle*
	SLO-2					
S-2	SLO-1	*Wind Energy - Introduction*	*Application of solar energy*	*Method of harnessing power and its potential in India*	*Setting of power plants*	*Limitations and principle of DEC*
	SLO-2					
S-3	SLO-1	*Application of wind energy*	*Transformation of solar energy*	*Hydropower – Properties and availability*	*Thermodynamic cycles*	*Thermo electric generators*
	SLO-2					
S-4	SLO-1	*Transformation of wind energy*	*Solar heat collectors*	*Transformation of water energy*	*Tidal and wave energy*	*Seebeck, peltier and joule Thompson effect and application*
	SLO-2					
S-5	SLO-1	*Wind Turbines*	*Solar photovoltaic collectors*	*Hydro power plants*	*Biomass - Principle of biomass conversion*	*Magneto hydrodynamic generator (MHD) – Working principle*
	SLO-2					
S-6	SLO-1	*Operating characteristics*	*Application of solar collectors*	*Applications of hydro power plants*	*Anaerobic/aerobic digestion*	*MHD accelerator, MHD engine*
	SLO-2					
S-7	SLO-1	*Wind power plant*	*Solar power plant*	*Special hydropower plants*	*Biogas digestors, gas yield and combustion characteristics*	*Electron gas dynamic conversion*
	SLO-2					
S-8	SLO-1	*Utilization of wind power*	*Economic study*	*Economic study*	*Utilization for cooking and economic aspects*	*Fuel cell – basic principle*
	SLO-2					
S-9	SLO-1	*Trends in wind energy utilization*	*Trends in solar energy utilization*	*Trends in hydro power utilization*	*Utilization in IC engine*	*Hybrid vehicle – Basic principle*
	SLO-2					

Learning Resources	1. *Boyle, Godfrey. 2004. Renewable Energy (2nd edition). Oxford University Press.*	2. *Boyle, Godfrey, Bob Everett, and Janet Ramage (eds.) 2004. Energy Systems and Sustainability: Power for a Sustainable Future. Oxford University Press, 619 pages (ISBN: 0-19-926179-2)*

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	*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. Sharath S Subramonian, McLanahan Corporation, ssharathi@mclanahan.com	*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. Ram Prasanth A, Caterpillar India Pvt Ltd, anjaneyulu_ram_p@cat.com	*2.Dr.S.Natrajan, Assistant Professor(Senior Grade),Mechanical Engineering, Sri Venkateswara College of Engineering,Email: natraj@svce.ac.in*	*2. Dr. V. Edwin Geo, SRMIST*

Course Code	18AUO103T	Course Name	SPECIAL TYPE OF VEHICLES	Course Category	O	Open 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 :	*Identify the special type of vehicles, their applications*
CLR-2 :	*Define the principles and design considerations of farm equipments*
CLR-3 :	*Define and Classify earth moving equipments*
CLR-4 :	*Identify the special vehicles used in construction industry*
CLR-5 :	*Classify the special application vehicles*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Acquire the knowledge of construction and operation of special type vehicle.*	*1,2*	*90*	*85*
CLO-2 :	*Understand the tractors operation principles and their types.*	*1,2*	*90*	*85*
CLO-3 :	*Know the fundamentals of earth moving machines and their types.*	*2*	*90*	*85*
CLO-4 :	*Applications of special type vehicles in construction industry for material handling.*	*3*	*85*	*80*
CLO-5 :	*Learn the basics of special application machines*	*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	*M*	*M*	*L*	*L*	*L*	*H*	*M*	*M*	*M*	*L*	*H*	*H*	*M*	*L*
H	*M*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*M*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*M*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*M*
H	*H*	*M*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*H*	*H*	*M*	*L*

		Off Road Equipments	Farm Equipments	Earth Moving Machines	Construction Equipments	Special purpose vehicles
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Classification of Special Purpose Vehicles,*	*Classification of farm equipments*	*Introduction of Earth moving equipments*	*Scrapers - Introduction*	*Introduction to special application machines*
	SLO-2	*wheel type & track type, applications*	*Introduction to tractors*	*capacity and applications of earthmovers*	*Scrappers Constructional Details, Applications*	*Power Shovel – Introduction and types*
S-2	SLO-1	*Transport Equipment: Powered Equipment, Trolleys, - Constructional Details, Applications*	*lay out of wheeled tractor*	*Basic considerations for equipment selection*	*Scrappers and their types*	*Power Shovel- Constructional details and applications*
	SLO-2	*Trailers Constructional Details, Applications*	*Classification of tractors*	*Bulldozers- Constructional details and operations and applications*	*Graders- Introduction*	*Drag lines*
S-3	SLO-1	*Platform Lift Trucks Constructional Details, Applications*	*Wheeled Tractor - Constructional Details, Applications*	*Types of Bull dozers*	*Motor graders Constructional Details, Applications*	*Revolving shovels –constructional details and applications*
	SLO-2	*Fork Lift Trucks Constructional Details, Applications*	*Crawler Tractor - Constructional Details, Applications*	*Cable And Hydraulic Dozers*	*Classifications of Motor graders*	*Stripper Shovels - constructional details and applications*
S-4	SLO-1	*Containers And Supports.- Constructional Details, Applications*	*Recent Trends In Tractor Design*	*Running And Steering Gears*	*Bush Cutters - Introductions*	*Capacity Of Shovels*
	SLO-2	*Hauling Equipment: Types Of Dump Trucks, On-High Way Vehicles, Constructional Details, Applications*	*Power transmission system In Caterpillar Tractor. – Mechanism*	*Dump Traction- Introduction*	*Bush Cutters- Constructional Details, Applications*	*Ditchers - Introduction*
S-5	SLO-1	*Off High Way Vehicles Constructional Details, Applications.*	*Steering system*	*Dump Trucks and their types*	*Stumpers -Introduction*	*Ditchers - constructional details and applications*
	SLO-2	*Hoisting Equipment: Jacks, Truck Mounted Crane*	*Accessories of wheeled tractors*	*Rigid Dump Trucks Constructional Details,*	*Stumpers - Constructional Details, Applications*	*Articulated vehicles- constructional details and applications*
S-6	SLO-1	*Crawler Constructional Details, Applications*	*Hydraulic control system*	*Articulated Dump Trucks Constructional Details*	*Dozer- Introduction*	*Ambulance*
	SLO-2	*Crane Constructional Details, Applications*	*Power take off unit.*	*Loaders: Single Bucket Constructional*	*Dozer-- Constructional Details,*	*fire extinguishing vehicle*

				Details, Applications	*Applications*	
S-7	SLO-1	*Outriggers. - Constructional Details, Applications*	*Motor Grader: Recent Trends*	*Multi Bucket Constructional Details, Applications*	*Rippers -Constructional Details, Applications*	*Hover craft*
	SLO-2	*Vibratory compactors Constructional Details, Applications*	*Control Mechanism Of A Caterpillar Motor Grader*	*Skid steer loaders constructional details and applications*	*Dragline Excavator -Introduction*	*oil tankers*
S-8	SLO-1	*Human factors in special purpose vehicle*	*Ride and stability characteristics*	*Trenchers- Introduction*	*Dragline Excavator - Constructional Details, Applications*	*Introduction to tankers*
	SLO-2	*Safety features*	*Safety features in tractors*	*Trenchers-Principles and operations*	*Vibratory roller - introduction*	*Special features and constructional details of tankers*
S-9	SLO-1	*Regulatory requirements of special purpose vehicles*	*Human factors in tractor design*	*criteria for selection of prime mover fro dumpers*	*Vibratory roller – Constructional details and applications*	*gun carriers - Introduction*
	SLO-2	*Economics of special purpose vehicle utilization*	*Procedure of testing and standard code for testing of tractor performance*	*criteria for selection of prime mover for front end loaders*	*Concrete mixer– Constructional details and applications*	*gun carriers - constructional details*

Learning Resources	*1. Wong J, "Terramechanics and Off-Road Vehicle Engineering", Butterworth-Heinemann, 2009* *2. "Off the Road Wheeled and Combined Traction Devices"., - Ashgate Publishing Co. Ltd. 1998* *3. Construction Equipment Management for Engineers, Estimators, and Owners, 1st Edition, CRC Press, 2006* *4. Rodhiev and Rodhiev, "Tractors and Automobiles", MIR Publishers, Moscow, 1984.*	*5. Abrosimov. K. Bran berg.A. and Katayer.K,"Road making Machinery", MIR Publishers, Moscow, 1971.* *6. RoviraMás, Francisco, Zhang, Qin, Hansen, Alan C, "Mechatronics and Intelligent Systems for Off-road Vehicles", Springer, 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 %*	-	*40%*	-	-	-	*30 %*	-	*30*	-
	Understand										
Level 2	Apply	*40 %*	-	*20%*	-	*60%*	-	*40 %*	-	*40*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20%*	-	*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.Ganeshkumar,Tafe,ganeshkumar@tafe.com	*1. Dr. P.D.Jeyakumar, Crescent Institute of Science and Technology>, pdjeyakumar@gmail.com*	*1.. Mr. N.Ganesh Kumar, SRMIST*
2. Mr.K.V.Simmom, Royal Enfield, kvsimmon1@royalenfield.com	*2.Dr.S.Ramkumar,Vel Tech, drsramkumar@veltech.edu*	*2. Mr. .S.Kiran,SRMIST*

Course Code	18AUO104T	Course Name	FUEL CELLS AND APPLICATIONS	Course Category	O	Open 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 fuel cell technology and applications*
CLR-2 :	*Know the concept of electrochemistry in fuel cells*
CLR-3 :	*Distinguish different types of fuel cells and operations*
CLR-4 :	*Inferring different hydrogen production techniques*
CLR-5 :	*Identify the application of fuel cells in power generation*

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 :	*Understand the basics of fuel cell technology*	*1,2*	*90*	*85*
CLO-2 :	*Infer the concepts of fuel cell electrochemistry*	*1,2*	*90*	*85*
CLO-3 :	*Classify the major types of fuel cells and their modes of operation*	*1,2*	*90*	*80*
CLO-4 :	*Categorize the methods of production, storage and utilization of hydrogen as a fuel*	*1,2*	*80*	*75*
CLO-5 :	*Gain knowledge on application of fuel cells in power cogeneration*	*1,2*	*90*	*85*

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*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
H	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
H	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
H	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*

		Introduction to fuel cells and fuel cell thermodynamics	Fuel cell electrochemistry	Types of fuel cells	Hydrogen production, storage and utilization	Application of fuel cells in power cogeneration
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction and overview of fuel cell technology*	*Introduction to electrode kinetics.*	*Classification of fuel cells*	*Hydrogen : Its merit as a fuel,*	*Balance of fuel cell power plant,*
	SLO-2	*A simple fuel cell, fuel cell advantages and disadvantages*	*Introduction to electrode kinetics.*	*Polymer electrolyte membrane fuel cell (PEMFC)*	*Production methods: from fossil fuels, electrolysis, thermal decomposition,*	*Balance of fuel cell power plant,*
S-2	SLO-1	*Basic fuel cell operation,*	*Fuel cell reaction kinetics*	*Electrodes and Electrode Structurein PEMFC*	*Production methods: from fossil fuels, electrolysis, thermal decomposition,*	*Fuel cell power plant structure*
	SLO-2	*Layout of a Real Fuel Cell*	*Fuel cell reaction kinetics*	*Water Management in the PEMFC*	*photochemical, photocatalytic*	*Cogeneration*
S-3	SLO-1	*The Hydrogen–Oxygen Fuel Cell with Liquid Electrolyte.*	*Conversion of chemical energy to electricity in a fuel cell.*	*PEMFuel Cell Cooling and Air Supply*	*Hybrid methods of hydrogen production*	*Fuel cell electric vehicles*
	SLO-2	*Difference between fuel cell and batteries, fuel choice*	*Conversion of chemical energy to electricity in a fuel cell.*	*Direct methanol fuel cells (DMFC)*	*Hydrogen storage methods:*	*Fuel cell in Motor cycles and bicycles, airplanes*
S-4	SLO-1	*Overview of types of fuel cells (with emphasis on PEMFC and DMFC technology)*	*Reaction rate of fuel cell*	*Anode, cathode Reaction and Catalysts in DMFC*	*Onboard hydrogen storage.*	*Case study: fuel cell vehicles with electric vehicles*
	SLO-2	*Fuel cell thermodynamics: Thermodynamics review*	*Reaction rate of fuel cell*	*Anode, cathode Reaction and Catalysts in DMFC*	*Chemical storage*	*Case study: fuel cell vehicles with electric vehicles*
S-5	SLO-1	*Application of first and second law to fuel cells*	*Butler -Volmer equation.*	*Methanol Production, Storage, and Safety*	*physical storage of hydrogen*	*Case study: different fuel cell powered Indian vehicles*
	SLO-2	*Heat Potential of a fuel*	*Butler -Volmer equation.*	*Methanol Production, Storage, and Safety*	*Storage in metal and alloy hydrides.*	*Case study: different fuel cell powered Indian vehicles*
S-6	SLO-1	*Enthalpy of reaction,*	*Fuel cell charge transfer*	*Alkaline fuel cell (PAFC)*	*Storage in metal and alloy hydrides.*	*Fueling stations*
	SLO-2	*Work potential of a fuel:*	*Fuel cell charge transfer*	*Types of Alkaline Electrolyte Fuel Cell*	*Carbon nanotubes*	*Fuel processor and fuel cell stack*

S-7	SLO-1	*Gibbs free energy*	*Mass transfer in fuel cells*	*Electrodes for Alkaline Electrolyte Fuel Cells*	*Carbon nanotubes*	*Water Management*
	SLO-2	*Predicting reversible voltage of a fuel cell under nonstandard-state conditions.*	*Mass transfer in fuel cells*	*Molten Carbonate fuel cell (MCFC)*	*Glass capillary arrays*	*Water Management*
S-8	SLO-1	*Basic Parameters of Fuel Cells.*	*Implications and use of fuel cell polarization curve*	*Molten Carbonate fuel cell (MCFC)*	*Glass capillary arrays*	*Thermal Management*
	SLO-2	*Fuel cell efficiency.*	*Implications and use of fuel cell polarization curve*	*Solid oxide fuel cell (SOFC)*	*pipeline storage*	*Thermal Management*
S-9	SLO-1	*Comparison with Carnot efficiency*	*Activation polarization, ohmic polarization*	*Comparison of fuel cell, Performance behavior*	*hydrogen utilization.*	*Safety issues and cost expectation*
	SLO-2	*Comparison with Carnot efficiency*	*Concentration Polarization, polarization losses*	*Comparison of fuel cell, Performance behavior*	*hydrogen utilization.*	*Safety issues and cost expectation*

Learning Resources	*1. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, "Fuel Cell Fundamentals", Wiley, 3rd edition 2016* *2. Viswanathan. B, AuliceScibioh, M, "Fuel Cells – Principles and Applications", Universities Press (India) Pvt., Ltd., 2009.*	*3. Bagotsky .V.S, "Fuel Cells",Wiley, 2009.* *4. DetlefStolten, "Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications", 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 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
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Course Code	18AUO105T	Course Name	TRANSPORT MANAGEMENT	Course Category	O	Open 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 :	*acquire knowledge about Motor Vehicle Act and Laws Governing Transport system*
CLR-2 :	*familiarize with Transport Taxation and Traffic controls.*
CLR-3 :	*know the various methods of fare charging and fleet management.*
CLR-4:	*acquire knowledge in Goods Transport system and Bus scheduling*
CLR-5:	*familiarize with insurance policies and vehicle maintenance.*

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 :	*.Able to understand and apply the Motor vehicle Act*	*1,2*	*90*	*85*
CLO-2 :	*Can able to get knowledge about ownership of vehicle and tax methods*	*1,2*	*90*	*85*
CLO-3 :	*Able to apply the knowledge about fleet management.*	*1,2*	*90*	*80*
CLO-4 :	*Thorough knowledge about various Goods vehicles and scheduling*	*1,2*	*80*	*75*
CLO-5 :	*Able to know the insurance claim and how to register accident case.*	*1,2*	*90*	*85*

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*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
H	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
H	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
H	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*

		Motor Vehicle Act	Transport systems and Taxation	Passenger Transport operation	Scheduling and Goods Transport operation	Vehicle Maintenance and insurance
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction – Motor Vehicle Act*	*Introduction – Transport systems and Taxation*	*Introduction – Passenger Transport operation*	*Introduction – scheduling and Goods Transport operation*	*Introduction – vehicle Maintenance and insurance*
	SLO-2	*Traffic rules and signals – fitness certificate*	*various transport systems.*	*Structure of passenger transport organisation*	*Scheduling - introduction*	*Preventive maintenance system in Transport industry*
S-2	SLO-1	*Registration of vehicle*	*Advantages of Motor Transport*	*Requirement on fleet management*	*Basic factors of Bus scheduling* *Problems in Bus scheduling*	*Tyre maintenance procedure* *Causes for uneven tyre wear*
	SLO-2	*Permit insurance*	*Areas of improvement in Motor Transportation*	*Problems on fleet management*		
S-3	SLO-1	*Constructional regulations of vehicles*	*Principal function of Administration*	*Fleet maintenance*	*Structure of Goods transport organisation*	*Remedies for tyre wear*
	SLO-2		*Functions of Traffic and Engineering divisions*	*Public relations - propaganda*	*Scheduling of Goods transport* *Management information system(MIS)*	*Maintenance procedure for better fuel economy*
S-4	SLO-1	*Government administration structure – personal, Authorities.*	*Chain of responsibility*	*Publicity and passenger amenities*	*Storage of petroleum products*	*Design of Bus depot layout.*
	SLO-2		*Forms of ownership by state Government.*	*Parcel traffic*	*Transportation of petroleum products*	*Insurance types - significance*
S-5	SLO-1	*Responsibilities of Driver, public - offences*	*Public body undertakings*	*Theory of Fares*	*Description of Tipper, tanker, power wagons vehicles*	*Comprehensive insurance*
	SLO-2	*Accidents – causes and analysis – preventive measures*		*Basic principle of fare charging*		*Third party insurance*
S-6	SLO-1	*State and interstate permits*	*Forms of ownership by municipality,private undertakings*	*Method of drawing up of a fare table*	*Description of recovery vans, delivery vans.*	*Furnishing of particulars of vehicle involved in accident*
	SLO-2	*Test for competence to drive*		*Various types of fare collecting methods*		*MACT – hit and run case*
S-7	SLO-1	*Licensing of Drivers and conductors*	*Taxation - objectives*	*Estimating the cost for transport vehicles*	*Advance technique in Traffic management*	*Solatium fund*
	SLO-2					

S-8	SLO-1	*Rules regarding construction of motor vehicles.*	*Structure of laving tax*	*Different rates for different type of service*	*Traffic navigation*	*Duty of Driver in case of accident.*
	SLO-2		*Methods of laving tax.*	*Principal features of operating cost*		*Surveyor and loss assessor*
S-9	SLO-1	*Laws Governing to use of Motor vehicle.*	*One time tax – Tax exemption*	*Operation cost - revenues*	*Global positioning system*	*Surveyor's report*
	SLO-2		*Tax renewal*	*Economics - records*		

Learning Resources	*1. "Motor vehicle Act" – Govt of India publications.* *2. Shrivastava s k, "Transport Development in India", S Chand & co Pvt Ltd., New Delhi* *3. John Duke, "Fleet Management", Mc Graw Hill, USA - 1984*	*4. Government Motor vehicle Act – Eastern Book Company, Lucknow – 1989* *5. Kitchin. L. D – Bus operation – ILLiffee and sons Co., London, 3rd edition - 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	*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
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2. Mr.A.Venugopal, WABCO, venugopal.a@wabco-auo.com	*2. Dr.T.R.Tamilarasan, Crescent Institute of Science and Technology, tamilarasanr@crescent.education*	*2. Mr. S. Palanisamy, SRMIST*

Course Code	18AUO106T	Course Name	COMPOSITE MATERIAL IN AUTOMOBILE APPLICATIONS	Course Category	O	Open 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 matrix material, reinforcements of polymer matrix composites, metal and ceramic matrix composites.*
CLR-2 :	*Understand the fundamentals of composite material strength and its mechanical behavior*
CLR-3 :	*Develop knowledge on processing, interfacial properties and application of 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 (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 basics of reinforcements and matrix material*	*1,2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-2 :	*Use of mathematical techniques to predict the macroscopic properties of different laminates*	*1,2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Choose suitable material to design composites*	*1,2*	*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*	*1,2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*	*L*	*L*	*H*	*H*	*H*
CLO-5 :	*Compare/evaluate the relative merits of using various conventional and composite materials for important engineering and other applications.*	*1,2*	*90*	*85*	*H*	*H*	*H*	*H*	*M*	*L*	*L*	*L*	*M*	*M*	*L*	*M*	*H*	*H*	*H*

		Introduction to composites	Polymer matrix composites	Metal matrix composites	Ceramic matrix composites	Advances in composites
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Fundamentals of composites*	*Reinforcement material-Fibres*	*Metallic Matrix Matrix*	*Ceramic Matrix Material*	*Carbon /Carbon composites*
	SLO-2	*Need for composites*	*Glass fibre, Carbon fibre-Processing*	*Selection of reinforcement*	*Failure Behavior of CMCs*	*Carbon Fiber Reinforcements*
S-2	SLO-1	*Classification of composites*	*Aramid fibre and Boron fibre-Processing*	*Processing of MMC*	*Toughening of CMCs*	*Matrix Systems-Thermosetting*
	SLO-2	*Advantages of Composite*	*Properties and Application*	*Liquid state processes*		
S-3	SLO-1	*Disadvantage of Composite*	*Particle reinforcement*	*Stir Casting, Squeeze Casting*	*Processing of CMCs*	*Thermoplastic and Gaseous precursor*
	SLO-2	*Properties of Composite:*	*Nano reinforcement*	*Slurry Casting, Melt Infiltration*	*Ceramic Particle Based Processes*	
S-4	SLO-1	*Particulate Composites*	*Polymer matrix material*	*Spray deposition*	*Cold Compaction*	*Processing of C/C Composites*
	SLO-2	*Fibre reinforced Composite*	*Thermosetting resins, thermoplastic resins*	*Solid state processes*	*Slurry Impregnation*	*Thermosetting Resin Based Processing*
S-5	SLO-1	*Elastic Behavior under Longitudinal Loading,*	*Fillers-Additives*	*Powder Metallurgy technique*	*Sol-gel Processing*	*Thermoplastic Pitch Based Processing*
	SLO-2	*Problems on Elastic Behavior under Longitudinal Loading,*	*Pre-Processed Material-Molding compound*	*Hot Pressing*	*Reaction Bonding Processes*	*Chemical Vapor Infiltration*
S-6	SLO-1	*Elastic Behavior under Transverse Loading*	*Prepegs-PMC processes*	*Diffusion Bonding*	*In Situ Ceramic Composite Processing*	*Properties of C/C Composites*
	SLO-2	*Problems on Elastic Behavior under Transverse Loading*	*Hand layup, Spray up processes*	*Gaseous state processes*	*Melt Processing*	*Oxidation Protection of C/C composites*

S-7	SLO-1	*Longitudinal Tensile Strength*	*Compression molding, Injection molding*	*Deposition techniques*	*Polymer Infiltration and Pyrolysis*	*Application of C/C Composites*
	SLO-2	*Transverse Tensile Strength*	*Autoclave molding*	*Machining and joining of MMCs*		*Nanocomposites*
S-8	SLO-1	*Discontinuous Fiber Reinforced Composites*	*Resin transfer molding*	*Properties of MMCs*	*Properties of CMCs*	*Polymer Nanocomposites*
	SLO-2		*Pultrusion, Filament winding*	*Parameters affecting properties of MMC*		*Metal Nanocomposites*
S-9	SLO-1	*Applications of composite*	*Properties of PMCs*	*Interfacial Problems*	*Automotive Application of CMCs*	*Ceramic Nanocomposites*
	SLO-2		*Automotive Application of PMCs.*	*Automotive Application of MMCs.*		*Nanocomposites- Properties and Applications*

Learning Resources	*1. Krishnan K Chawla, Composite Materials: Science and Engineering, International Edition, Springer, 2012.* *2. Mallick, P.K. and Newman.S, Composite Materials Technology, Hanser Publishers, 2003.* *3. M. Balasubramanian, "Composite Materials and Processing", CRC press, Taylor and Francis Group, 2014.*	*4. Sanjay K Mazumdar, "Composites Manufacturing: Materials, Product and Process Engineering", CRC Press, New York, 2010.* *5. 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	*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
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Course Code	18AUO107T	Course Name	NON DESTRUCTIVE TESTING AND EVALUATION	Course Category	O	Open 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 principle, importance and applications of various NDT techniques*
CLR-2 :	*Acquire proper skills and equip with proper competencies to locate flaws in various materials and products.*
CLR-3 :	*Equip themselves familiar with industrial 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 :	*Understand various Non Destructive Techniques to detect defects*	*1*	*90*	*90*	*H*	*M*	*L*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*L*	*M*	*H*	*M*	*M*
CLO-2 :	*Apply scientific and technical knowledge to the field of non-destructive testing*	*1,2*	*90*	*80*	*H*	*H*	*M*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*H*
CLO-3 :	*Use the relevant non-destructive testing methods for various engineering practice*	*1,2*	*85*	*85*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-4 :	*Recognize and achieve high levels of professionalism in their work*	*1,2*	*90*	*80*	*H*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*
CLO-5 :	*Engage in lifelong learning, thought process and development*	*1.2*	*85*	*90*	*H*	*M*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*H*

		Overview of NDT	Surface NDE Methods	Thermography and Eddy Current Testing	Ultrasonic Testing (UT) and Acoustic Emission	Radiography
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to NDT*	*Liquid Penetrate Testing-Principle, Characteristics and types of penetrant*	*Principle of Thermography,*	*Ultrasonic Testing-Introduction, Basic Properties of sound beam, Acoustic Impedance*	*Radiography- Principle*
	SLO-2			*IR-radiation-Properties, Factors affecting Thermal measurements*		*Electromagnetic radiation sources*
S-2	SLO-1	*Comparison of Destructive and Non Destructive Methods*	*Developers-Function, Properties and types*	*Contact and non contact temperature sensors*	*Ultrasonic Transducers,*	*Radiation Attenuation and Effect of radiation on film*
	SLO-2					
S-3	SLO-1	*Overview of Non Destructive Testing Methods*	*Cleaning Methods and Emulsifiers*	*Non Contact Thermography System*	*Inspection Methods-Transmission and pulse-echo method*	*Radiographic Imaging*
	SLO-2					
S-4	SLO-1	*Casting Defects*	*Liquid penetrant Testing procedure and Interpretation of results*	*Advantages, Disadvantages and applications of Thermography*	*Inspection Methods- Angle beam pulse echo method*	*Inspection Techniques- Single wall and double wall penetration techniques*
	SLO-2					
S-5	SLO-1	*Welding Defects*	*Penetrant Removal Process, Advantage and Limitation of Liquid penetrate Test*	*Eddy Current Testing-Introduction and principle*	*Ultrasonic Flaw Detection Equipment, Mode of Display-A-Scan, B-scan, C-scan*	*Inspection Techniques-Multiwall penetration technique*
	SLO-2					
S-6	SLO-1	*Visual Testing-Principle and Tools*	*Magnetic Particle Testing-Introduction, Method of Magnetization*	*Factors affecting eddy current*	*Advantages, limitations and application of Ultrasonic testing method*	*Advantages, disadvantages and applications of radiography*
	SLO-2					
S-7	SLO-1	*Optical Aid used for Visual Inspection-Microscope, Rigid Borescope, Mini and Hybrid Borescope*	*Procedure for Magnetic Particle Testing*	*Instrumentation of eddy current testing*	*Acoustic Emission Testing-Principle and Technique*	*Real time Radiography-Microfocal Radiography*

	SLO-2					
S-8	SLO-1	*Optical Aid used for Visual Inspection- Extendable borescope, Flexible borescope, Endoscope, Telescope and Holography*	*Residual Magnetism.*	*Types of probes*	*Instrumentation of Acoustic Emission Testing*	*Advantages and limitations of Microfocal Radiography*
	SLO-2					
S-9	SLO-1	*Merits and Demerits of Visual Testing*	*Demagnetization-Method of Demagnetization*	*Advantages, Limitations and application of eddy current testing*	*Applications*	*Xero Radiography*
	SLO-2					

Learning Resources	*1. Baldev Raj, T.Jayakumar, M.Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing, 3rd Edition, 2014* *2. Ravi Prakash, "Non-Destructive Testing Techniques", 1st revised edition, New Age International Publishers, 2010* *3. ASM Metals Handbook, "Non-Destructive Evaluation and Quality Control",American Society of Metals, Park, Ohio, USA, 200, Volume-1, 2018..*	*4. Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005* *5. Charles, J. Hellier, "Handbook of Nondestructive evaluation", McGraw Hill, New York, 2nd Edition, 2013.*

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		
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2. Mr. R. Silambarasan, RNTBCI, silambarasan.ramadoss@rntbci.com	*2. Dr. D. Muruganandham, SVC of Tech, svctvp@gmail.com*	*2.Mr. P. BaskaraSethupathi, SRMIST, sethupab@srmist.edu.in*

Course Code	18AUO108T	Course Name	ADVANCED ENGINE TECHNOLOGY	Course Category	O	Open 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	*Explore the sustainable development, energy conservation, efficiency and environmental preservation.*
CLR-2 :	*Provide a comprehensive reference to understand the current trends in Advanced engines*

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 knowledge about the Thermodynamic Analysis of SI Engine Combustion process.*	*2*	*90*	*90*	*H*	*H*	*M*	*H*	*L*	*L*	*M*	*L*	*H*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-2 :	*Acquire knowledge about the Thermodynamic Analysis of CI Engine Combustion process.*	*2*	*90*	*90*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*
CLO-3 :	*Understand the Various Fuel injection system for SI & CI engine*	*2*	*90*	*90*	*H*	*M*	*H*	*H*	*M*	*H*	*L*	*L*	*H*	*M*	*H*	*M*	*H*	*M*	*H*
CLO-4 :	*Gain knowledge about the engine modification required for alternative fuels.*	*2*	*90*	*90*	*M*	*H*	*M*	*M*	*H*	*M*	*H*	*H*	*M*	*L*	*H*	*M*	*H*	*M*	*H*
CLO-5 :	*Acquire knowledge about recent trends in IC engines.*	*2*	*90*	*90*	*H*	*H*	*M*	*H*	*L*	*H*	*M*	*L*	*L*	*H*	*M*	*M*	*H*	*M*	*H*

		Spark Ignition Engines	Compression Ignition Engines	Fuel systems	Alternate Fuels	Recent Trends
Duration (hour)		9	9	9	9	9
S-1	SLO1	*Introduction to Spark ignition engines*	*Introduction to Compression Ignition Engines*	*Introduction to Fuel Injection System*	*Introduction to Engine Modifications For Alternative Fuels*	*Recent Trends*
	SLO2	*Air-Fuel Ratio Requirements*	*Stages Of Combustion in CI Engine*	*Fuel Injection System Functions And Components*	*Alternative fuels Properties , Suitability*	*Homogeneous Charge Compression Ignition Engine*
S-2	SLO1	*Design Of Carburetor*	*Stages Of Combustion in CI Engine*	*Petrol Injection - Open Loop Systems*	*Alcohols as a Fuel for IC engines*	*Homogeneous Charge Compression Ignition Engine*
	SLO2	*Carburetor –Fuel Jet Size And Venture Size*	*Normal And Abnormal Combustion – Factors Affecting Knock*	*Petrol Injection - Closed Loop Systems*	*Vegetable Oils And Bio-Diesel*	*Lean Burn Engine*
S-3	SLO1	*Carburetor –Fuel Jet Size And Venture Size*	*Normal And Abnormal Combustion – Factors Affecting Knock*	*Mono Point And Multi Point Injection System*	*Bio-Gas*	*Lean Burn Engine*
	SLO2	*Stages Of Combustion*	*Direct And Indirect Injection Systems*	*Mono Point And Multi Point Injection System*	*Natural Gas*	*Stratified Charge Engine*
S-4	SLO1	*Stages Of Combustion*	*Direct And Indirect Injection Systems*	*Direct Injection Systems*	*Liquefied Petroleum Gas*	*Stratified Charge Engine*
	SLO2	*Normal And Abnormal Combustion*	*Combustion Chambers*	*Fuel Injection In-Line, Rotary Pumps*	*Liquefied Petroleum Gas*	*Surface Ignition Engine*
S-5	SLO1	*Normal And Abnormal Combustion*	*Combustion Chambers*	*Testing-Governing- Injection Lag*	*Hydrogen as a fuel in IC engines*	*Surface Ignition Engine*
	SLO2	*Factors Affecting Knock*	*Turbo Charging*	*Fuel Injector - Types Of Injection Nozzle*	*Hydrogen as a fuel in IC engines*	*Four Valve And Overhead Cam Engines*
S-6	SLO1	*Combustion Chambers*	*Turbo Charging*	*Fuel Injector - Types Of Injection Nozzle*	*Engine Modifications*	*Four Valve And Overhead Cam Engines*
	SLO2	*Combustion Chambers*	*Introduction To Thermodynamic Analysis Of CI Engine*	*Fuel Spray Characteristics*	*Engine Modifications*	*Four Valve And Overhead Cam Engines*

S-7	SLO1	*Introduction To Thermodynamic Analysis Of SI Engine*	*Thermodynamic Analysis Of CI Engine*	*Fuel Injection Timing*	*Performance, emission and combustion characteristics of SI engines*	*Alternative Power Sources: Wankel Rotary Engine*
	SLO2	*Thermodynamic Analysis Of SI Engine*	*Combustion Process in CI Engines*	*Factors Influencing Fuel Spray Atomization, Penetration And Dispersion Of Diesel*	*Performance, emission and combustion characteristics of SI engines*	*Sterling Engine, Gas Turbine Engine*
S-8	SLO1	*Thermodynamic Analysis Of SI Engine*	*Combustion Process in CI Engines*	*Factors Influencing Fuel Spray Atomization, Penetration And Dispersion Of Diesel*	*Performance, emission and combustion characteristics of CI engines*	*Sterling Engine, Gas Turbine Engine*
	SLO2	*Thermodynamic Analysis Of SI Engine Combustion Process*	*Combustion Process in CI Engines*	*Electronic Engine Management system*	*Performance, emission and combustion characteristics of CI engines*	*Cycle test-I*
S-9	SLO1	*Recent Developments In SI Engines*	*Recent Developments In CI Engines*	*Electronic Engine Management System*	*Alternative fuels used in CI engines*	*Cycle test-II*
	SLO2	*Recent Developments In SI Engines*	*Recent Developments In CI Engines*	*Common Rail Direct Injection Diesel Engine*	*Alternative fuels used in CI engines*	*Surprise test*

Learning Resources	1. *Heinz Heisler, "Advanced Engine Technology"., SAE International Publications, USA,1998* 2. *Ganesan V. "Internal Combustion Engines"., Third Edition, Tata Mcgraw-Hill ,2007* 3. *John B Heywood. "Internal Combustion Engine Fundamentals"., Tata McGraw-Hill 1988*	4. *Patterson D.J. and Henein N.A,"Emissions from combustion engines and their control"., Ann Arbor Science publishers Inc, USA,* 5. *Gupta H.N, "Fundamentals of Internal Combustion Engines". ,Prentice Hall of India, 2006* 6. *Ultrich Adler , "Automotive Electric / Electronic Systems"., Published by Robert Bosh GmbH,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	*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
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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.T.Prakash, SRM IST*

Course Code	18AUO109T	Course Name	NEW PRODUCT DEVELOPMENT	Course Category	O	Open 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 new product process*
CLR-2 :	*learn and apply the concepts and tools necessary through case examples and assignments*
CLR-3 :	*actually use the new product development process by conceiving your own new product or service and introductory launch plan*

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 :	*Develop familiarity with models of innovation and the marketing and technology interface*	*1,2*	*85*	*80*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	
CLO-2 :	*Understand the importance of new product development to firm performance*	*1,2*	*80*	*75*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	
CLO-3 :	*Learn methods of generating, evaluating and testing product ideas*	*1,2*	*85*	*80*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*H*	*M*	*H*	
CLO-4 :	*Identify relevant components and plan a product launch*	*1,2*	*80*	*75*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*	*H*	*M*	*H*	*M*	
CLO-5 :	*Learn methods of evaluating and monitoring the success of a launch*	*1.2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*M*	*M*	*H*	

		Project Selection and Evaluation	New Product Resources	New Product Planning	New Product Development	Product Architecture
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Collection Of Ideas*	*Technological Research*	*Design Of Prototype*	*Journeys In Product Development*	*Establishing the Product architecture*
	SLO-2					
S-2	SLO-1	*Purpose Of Project*	*Basic concepts and need for Intellectual Property*	*Testing of prototype*	*Product Development Process Tools*	*creation*
	SLO-2					
S-3	SLO-1	*Selection Criteria*	*Patents*	*Quality Standards*	*Scoping Product Developments*	*clustering*
	SLO-2					
S-4	SLO-1	*Screening Ideas For New Products*	*Patent Search*	*Marketing Research*	*Technical And Business Concerns*	*geometric layout development*
	SLO-2					
S-5	SLO-1	*Creative design*	*Patent Laws*	*Introducing New Products*	*Understanding Customer Needs*	*fundamental and incidental interactions*
	SLO-2					
S-6	SLO-1	*Model Preparation*	*International Code For Patents*	*Integrate process design*	*Establishing Product Function*	*related system level design issues*
	SLO-2					
S-7	SLO-1	*Testing*	*Intellectual Property Rights (IPR)*	*Managing costs*	*involve customer in development and managing requirements*	*secondary systems*
	SLO-2					
S-8	SLO-1	*Cost evaluation*	*Copyrights*	*Robust design*	*process management and improvement*	*architecture of the chunks*
	SLO-2					
S-9	SLO-1	*Patent application*	*Geographical Indications*	*Integrating CAE, CAD, CAM tools*	*Plan and establish product specifications*	*creating detailed interface specifications*
	SLO-2					

Learning Resources	1. *Paul trott "Innovation Management and New Product Development" 5th Edition Sep 2011* 2. *Barclay, Z. Dann, P. Holroyd, "New Product development" I, Published by BH Butterworth-Heinemann a division of Reed Educational and professional publishing limited.2000.*	3. *Marc Annacchino "New Product Development " 1st Edition Sep 2003* 4. *Brain Twiss, "Managing technological innovation", Pitman Publishing Ltd., 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	*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. A. Prasad, Mahindra and Mahindra, PRASAD.ARUNKUMAR@mahindra.com	*1. Dr. A. Krishnaveni, Govt. College of Engineering, Tirunelveli, krishnaveni@gcetly.ac.in*	*1. Dr. J. Chandradass, SRMIST , chandraj@srmist.edu.in*
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Course Code	18AUO110T	Course Name	AUTOMOTIVE STANDARDS AND REGULATIONS	Course Category	O	Open 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 :	*Impart knowledge on basics of automobile standards and regulations.*			
CLR-2 :	*Know the various safety standards on collision.*			
CLR-3 :	*Gain knowledge about various safety standards in automotive electrical systems.*			
CLR-4 :	*Understand the regulations used in hybrid and electric vehicles.*			
CLR-5 :	*Impart knowledge on regulations used in gaseous fuel vehicles.*			
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Gain knowledge about basic automobile standards and regulations.*	*1*	*80*	*75*
CLO-2 :	*Gain knowledge about standards for safety during collision.*	*2*	*75*	*70*
CLO-3 :	*Understand the various standards used for automotive electrical systems.*	*2*	*80*	*77*
CLO-4 :	*Gain knowledge about the regulations used for hybrid and electric vehicles.*	*3*	*75*	*70*
CLO-5 :	*Gain knowledge about the regulations used for gaseous fuel vehicles.*	*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
M	*L*	*L*	*L*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*H*	*H*	*L*	*L*
M	*L*	*L*	*L*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*L*	*H*	*M*	*L*
M	*L*	*L*	*L*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*L*	*L*
M	*L*	*L*	*L*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*M*	*H*	*M*	*M*
M	*L*	*L*	*L*	*M*	*M*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*M*	*L*

		General Automotive Standards and Regulations	Collision Safety Standards	Automotive electrical Standards	Electric and Hybrid Vehicle Standards	CNG, LPG Vehicles and Engine Emission Standards
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Procedure for Type Approval and Certification of Vehicles for Compliance to Central Motor Vehicles Rules.*	*Bumper Fitment on Vehicles – Test Methods.*	*Testing Procedure and Requirements for Headlamp Beam.*	*Battery Operated Vehicles – Requirements for Construction and Functional Safety.*	*Safety and Procedural Requirements for Type Approval of CNG Operated Vehicles.*
	SLO-2					
S-2	SLO-1	*Speed Limitation Devices and Its Specifications.*	*Safety Belt Assemblies, Safety Belt Anchorages –Specifications.*	*Approval of Front Position Lamps, Rear Position Lamps, Stop Lamps, Direction Indicators, Rear Registration Plate Illuminating Devices and Reversing Lamp.*	*Measurement of Electrical Energy Consumption.*	*Safety and Procedural Requirements for Type Approval of CNG Operated Vehicles.*
	SLO-2					
S-3	SLO-1	*Arrangement of Foot Controls of Vehicles.*	*Seats, their Anchorages and Head Restraints Specifications, Survival Space for the Protection of the Occupants.*	*Provisions Concerning the Approval of Headlamps Equipped with Gas Discharge Light Sources.*	*Method of Measuring the Range.*	*Safety and Procedural Requirements for Type Approval of LPG Operated Vehicles.*
	SLO-2					
S-4	SLO-1	*Starting Grade-Ability - Method of Measurement and Requirements.*	*Requirements for Behaviour of Steering Mechanism of a Vehicle in a Head-On Collision.*	*Provisions Concerning the Approval of Light Emitting Diode(LED) Light Sources For use in Approved Lamp Units.*	*Measurement of Net Power andthe Maximum 30 Minute Power and Speed.*	*Safety and Procedural Requirements for Type Approval of LPG Operated Vehicles.*
	SLO-2					
S-5	SLO-1	*Protective Helmets for Motor Cycle Riders.*	*Procedure for Determining the "H" Point and The Torso Angle in Seating Positions of Motor Vehicles.*	*Lighting, Signalling & Indicating Systems on Motor Vehicles.*	*Electric Power Train - Requirements for Construction and Functional Safety.*	*Code of Practice for use of LPG Fuel in Internal Combustion Engine to Power 4 Wheeled Vehicles.*
	SLO-2					
S-6	SLO-1	*Protective Helmets and Visors for Motorcycle Riders – Specification.*	*Requirements for the Protection of the Occupants in the Event of an Offset Frontal Collision.*	*Performance Requirements of Lighting and Light-Signalling Devices.*	*Measurement of Electrical Energy Consumption.*	*Code of Practice for use Of LPG Fuel in Internal Combustion Engine to Power 2 & 3 Wheeled Vehicles.*
	SLO-2					
S-7	SLO-1	*Two Wheeled Vehicles – Location, Identification and Operation of Controls, Tell-Tales and Indicators.*	*Approval of Vehicles with Regards to the Protection of the Occupants in the Event of a Lateral Collision.*	*Testing Standards for Wind Screen Wiping System.*	*Method of Measuring the Range.*	*Code of Practice for use of CNG Fuel in Internal Combustion Engine to Power 4 Wheeled Vehicles.*
	SLO-2					

S-8	SLO-1 SLO-2	*Procedure for Type Approval and Establishing Conformity of Production for Safety Critical Components.*	*Requirements for the Protection of Pedestrian and Other Vulnerable Road Users in the Event of a Collision with a Motor Vehicle.*	*Horn Installation Requirement.*	*Measurement of Net Power and The Maximum 30 Minute Power and Speed.*	*Code of Practice for use of CNG Fuel in Internal Combustion Engine to Power 2 & 3 Wheeled Vehicles.*
S-9	SLO-1 SLO-2	*NCAP And BNVSAP Ratings, Requirements for School Buses.*	*Requirements for the Protection of Fuel System in The Event of Rear Impact of a Motor Vehicle.*	*Electronic Stability Control Systems.*	*CMVR Type Approval for Hybrid Electric Vehicles, CMVR Type Approval of Vehicles Retrofitted with Hybrid Electric System.*	*Bharath and Euro Emission Norms.*

Learning Resources	1. ARAI publications "\Automotive industry standards", April 30, 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 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
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Course Code	18AUO111T	Course Name	AUTOMOTIVE SCIENCES	Course Category	O	Open 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
CLR-1 :	*Understand the ability and information to follow recent developments about the internal combustion engine technology.*	1
CLR-2 :	*Describe methods for reduction of exhaust emissions, and their relations to fuel quality and engine performance*	2
CLR-3 :	*Demonstrate competency in skills related to automotive technology.*	3

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 Insights in Internal Combustion Engine*	*1*	*90*	*90*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*L*	*M*	*H*	*H*	*M*	*H*
CLO-2 :	*Summarize the Knowledge in Engine Cycles*	*2*	*90*	*90*	*H*	*H*	*H*	*H*	*M*	*M*	*M*	*M*	*H*	*L*	*H*	*H*	*H*	*L*	*M*
CLO-3 :	*Compare the technology in emissions*	*2*	*90*	*90*	*H*	*M*	*H*	*M*	*H*	*H*	*M*	*H*	*M*	*L*	*H*	*H*	*H*	*H*	*L*
CLO-4 :	*Demonstrate the Relationship in Velocity, Acceleration and Speed*	*2*	*90*	*90*	*H*	*H*	*M*	*H*	*H*	*L*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*L*
CLO-5 :	*Explain the technology of Vehicle Characteristics*	*2*	*90*	*90*	*H*	*H*	*H*	*H*	*H*	*M*	*L*	*M*	*H*	*L*	*H*	*H*	*H*	*H*	*M*

Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Internal combustion engines*	*Theoretical engine cycles*	*Fuels and combustion & emissions*	*Velocity and acceleration, speed*	*Vehicle Characteristics*
	SLO-2	*Engine power and Brake power*	*The constant volume cycle (Otto cycle)*	*combustion*	*Speed and velocity Acceleration*	*Load transfer under acceleration*
S-2	SLO-1	*Dynamometers for high-speed engines*	*Thermal efficiency of the theoretical Otto cycle*	*Products of combustion*	*Velocity–time graph Uniform velocity*	*Static reactions*
	SLO-2	*Mean effective pressure*	*Thermal efficiency in terms of compression ratio r*	*Relevant combustion equations*	*Uniform acceleration*	*Vehicle under acceleration*
S-3	SLO-1	*Horsepower PS – the DIN*	*Effect of compression ratio on thermal efficiency*	*Air–fuel ratio Petrol engine combustion*	*Equations of motion and their application to vehicle technology*	*Vehicle acceleration – effect of load transfer*
	SLO-2	*Indicated power Mean effective pressure*	*Relative efficiency*	*Detonation, Pre-ignition*	*Force, mass and acceleration*	*Front wheel drive*
S-4	SLO-1	*Cylinder pressure vs. crank angle*	*Diesel or constant pressure cycle*	*Octane rating*	*Relation between mass and weight*	*Maximum acceleration – rear wheel drive*
	SLO-2	*Mechanical efficiency of an engine*	*Diesel or constant pressure cycle*	*Compression ignition engine combustion chambers*	*Inertia*	*Four wheel drive – fixed*
S-5	SLO-1	*Morse test*	*The dual combustion cycle*	*Diesel fuel-Flash point*	*Motion under gravity*	*Four wheel drive – with third differential*
	SLO-2	*Characteristic curves of engine performance*	*Operation of dual combustion cycle*	*Pour point-Cloud point*	*Angular (circular) motion*	*Four wheel drive – with third differential*
S-6	SLO-1	*Volumetric efficiency*	*Comparison between theoretical and practical engine cycles*	*Exhaust emissions-Factors affecting exhaust emissions*	*Equations of angular motion*	*Accelerating force – tractive effort*
	SLO-2	*Torque vs. engine speed*	*Comparison between theoretical and practical engine cycles*	*Emissions and their causes*	*Equations of angular motion*	*Tractive resistance*
S-7	SLO-1	*Specific fuel consumption vs. engine speed*	*The Stirling engine regenerator*	*Methods of controlling exhaust emissions*	*Relation between angular and linear velocity*	*Power required to propel vehicle*
	SLO-2	*Brake power, torque and sfc compared*	*A double-acting Stirling engine*	*Exhaust gas recirculation*	*Relation between angular and linear velocity*	*Gradeability*
S-8	SLO-1	*Thermal efficiency*	*The gas turbine*	*Catalysts*	*Centripetal acceleration*	*Vehicle power on a gradient*
	SLO-2	*Indicated thermal efficiency*	*The gas turbine*	*Diesel particulate filters*	*Accelerating torque*	*Vehicle on a curved track*
S-9	SLO-1	*Brake thermal efficiency petrol vs. diesel*	*Summary of formulae*	*Liquefied petroleum gas (LPG)*	*Model problem I*	*Overturning speed*
	SLO-2	*Heat energy balance*	*Simple Problems*	*Zero emissions vehicles (ZEVs)*	*Model problem II*	*Skidding speed*

Learning Resources	1. *Allan Bonnick "Automotive Science and Mathematics "Published by Elsevier Ltd First edition 2008* 2. *Willard W. Pulkrabek "Engineering Fundamentals of the Internal Combustion Engine" Pearson; 2 edition (10 June 2003)*	3. *N. K. Giri "Automobile Technology" Khanna Publishers; 2nd edition edition (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
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2. Mr.S.Ravi Kumar, ARK INFO SOLUTIONS, mymail2ravi@ymail.com	*2. Mr.A.Muthuvel, Muthuvel.mech@sairamce.edu.in*	*2. Mr.S.MadhanKumar, SRMIST,madhanks@srmist.edu.in*

Course Code	18AUO112T	Course Name	INTELLIGENT VEHICLE TECHNOLOGY	Course Category	O	Open 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 :	*Acquire knowledge of about Intelligent vision system*
CLR-2 :	*Know the architecture of Intelligent transportation system*
CLR-3 :	*Impart the techniques of adaptive control*
CLR-4 :	*Know the architecture for autonomous vehicles*
CLR-5 :	*Study the autonomous vehicle cases*

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 :	*Understand the intelligent vision system used in automobiles*	*2*	*85*	*75*
CLO-2 :	*Understand the architecture of intelligent transportation system*	*2*	*80*	*75*
CLO-3 :	*Understand adaptive control techniques of an autonomous vehicle*	*2*	*90*	*85*
CLO-4 :	*Understand about the successful autonomous vehicle projects*	*2*	*85*	*80*
CLO-5 :	*Know the case studies of Autonomous vehicle*	*2*	*80*	*75*

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*	*H*	*L*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*H*	*H*	*H*	*H*
H	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*M*	*L*	*M*	*H*	*H*	*H*
H	*H*	*H*	*H*	*L*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*H*	*H*	*M*
H	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
H	*M*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*

		Introduction to Intelligent Vision System	Vehicle Information System and Intelligent Transportation	Adaptive Control Techniques for Intelligent Vehicles	Decisional Architectures for Autonomous Vehicles	Autonomous Vehicle and Case Studies
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Vision Based Driver Assistance System – Vehicle optical Sensor*	*Intelligent Transportation System (ITS) –*	*Automatic Control Of Highway Traffic And Moving Vehicles*	*Control Architectures*	*DARPA Challenge Case Study*
	SLO-2	*Vision Based Driver Assistance System – Laser Radar*	*Vision for ITS Communications*	*Automatic Control Of Highway Traffic And Moving Vehicles*	*Motion Autonomy*	*DARPA Challenge Case Study*
S-2	SLO-1	*Non Contact ground velocity detecting Sensor*	*Multimedia communication in a car*	*Adaptive Control Of Highway Traffic And Moving Vehicles*	*Deliberative Architectures,*	*ARGO Prototype Vehicle*
	SLO-2	*Road Surface Recognition Sensor*	*Multimedia communication in a car*	*Adaptive Control Of Highway Traffic And Moving Vehicles*	*Deliberative Architectures,*	*ARGO Prototype Vehicle*
S-3	SLO-1	*Vehicle Sensors for Electronic Toll Collection System*	*Current ITS Communication Systems and Services*	*Adaptive Control Overview*	*Reactive Architectures,*	*The Gold System*
	SLO-2	*Vehicle Sensors for Electronic Toll Collection System*	*Current ITS Communication Systems and Services*	*Gain Scheduling*	*Reactive Architectures,*	*The Gold System*
S-4	SLO-1	*Components of a Vision Sensor System*	*Vehicle to Vehicle Communication Systems*	*Model Reference Adaptive Control*	*Hybrid Architecture Overview.*	*The inverse Perspective Mapping*
	SLO-2	*Components of a Vision Sensor System*	*Vehicle to Vehicle Communication Systems*	*Model Reference Adaptive Control*	*Hybrid Architecture Examples*	*Lane Detection*
S-5	SLO-1	*Driver Assistance on Highways –Lane Recognition*	*Road to Vehicle Communication Systems*	*Self-Tuning Adaptive Control System Model*	*Overview Of Sharp Architecture,*	*Obstacle Detection*
	SLO-2	*Driver Assistance on Highways –Lane Recognition*	*Road to Vehicle Communication Systems*	*Self-Tuning Adaptive Control System Model*	*Models Of Vehicles*	*Vehicle Detection*
S-6	SLO-1	*Driver Assistance on Highways –Traffic Sign Recognition*	*Inter Vehicle Communication*	*System Identification Basics,*	*Concepts Of Sensor Based Maneuver,*	*Pedestrian Detection*

	SLO-2	*Driver Assistance on Highways –Traffic Sign Recognition*	*Inter Vehicle Communication*	*Recursive Parameter Estimation,*	*Reactive Trajectory Following, ,*	*Software systems architecture*
S-7	SLO-1	*Driver Assistance in Urban Traffic-Stereo Vision*	*Intra Vehicle Communication*	*Estimator Initialization*	*Parallel Parking*	*Computational Performances*
	SLO-2	*Driver Assistance in Urban Traffic-Stereo Vision*	*Intra Vehicle Communication*	*Design Of Self-Tuning Controllers*	*Platooning*	*ARGO Prototype vehicle Hardware*
S-8	SLO-1	*Driver Assistance in Urban Traffic- Shape base analysis*	*VANETS-Devices*	*Generalized Minimum Variance (GMV) Control*	*Main Approaches To Trajectory Planning,*	*Functionalities- ARGO Prototype vehicle*
	SLO-2	*Driver Assistance in Urban Traffic- Shape base analysis*	*Optical Technologies*	*Pole Placement Control*	*Main Approaches To Trajectory Planning,*	*Data acquisition System,*
S-9	SLO-1	*Driver Assistance in Urban Traffic-Pedestrian Recognition*	*Millimeter Wave technologies*	*Model Predictive Control Overview*	*Non-Holonomic Path Planning.*	*Processing System*
	SLO-2	*Driver Assistance in Urban Traffic-Pedestrian Recognition*	*Millimeter Wave technologies*	*Model Predictive Control Examples*	*Non-Homonymic Path Planning.*	*Control System Overview*

Learning Resources	1. *LjuboVlacic, Michel Parent and Fumio Harashima,"Intelligent Vehicle Technologies", Butterworth-Heinemann publications, Oxford, 2001-ISBN 0 7506 5093 1* 2. *Ronald K Jurgen, "Automotive Electronics Handbook ", Automotive Electronics Series, SAE, USA, 1998.*	3. *NicuBizon,Lucian D Ascalescu And NaserMahdavitAbatabaei "Autonomous 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	*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 %		-	

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	18CHO101T	Course Name	SUSTAINABLE ENERGY ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize various ways of collecting solar energy and its applications*
CLR-2 :	*Familiarize various ways of utilizing wind energy*
CLR-3 :	*Familiarize various aspects of Biomass energy and utilization*
CLR-4 :	*Understand the current status and future trends in energy*
CLR-5 :	*Appreciate the need for efficient energy storage and distribution*
CLR-6 :	*Understand the various means of utilizing energy for sustainable development*

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 :	*Know the different industrial solar equipments for heat and electricity*	*1*	*80*	*75*
CLO-2 :	*Know the types of wind mill and their design*	*1*	*80*	*75*
CLO-3 :	*Comprehend the uses of energy from biomass and reactor design*	*1*	*80*	*75*
CLO-4 :	*Apply the concept of energy transfer to modern processes*	*2*	*70*	*65*
CLO-5 :	*Comprehend the various means of energy storage and distribution*	*2*	*75*	*65*
CLO-6 :	*Apply the knowledge of sustainable resources for efficient energy utilization and storage*	*2*	*70*	*65*

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
L	*M*	*H*	*L*			*H*						*H*	*L*	*M*
L	*M*	*H*	*L*			*H*						*H*	*L*	*M*
L	*M*	*H*	*L*			*H*						*H*	*L*	*M*
H	*H*	*H*	*H*			*H*						*H*	*H*	*H*
H	*H*	*H*	*H*			*H*						*H*	*H*	*H*
H	*H*	*H*	*H*			*H*						*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction on solar energy*	*Availability of wind*	*Biomass, Biomass resources*	*Current and future state of energy - Introduction*	*Energy storage and distribution - Introduction*
	SLO-2	*Solar angles*	*Special features of wind energy*	*Composition, fuel properties*	*Current and future state of energy - Introduction*	*Energy storage systems*
S-2	SLO-1	*Solar collectors*	*Types of wind mills*	*Biomass conversion technologies*	*Basic thermodynamic functions and applications*	*Mechanical energy storage*
	SLO-2	*Types of collectors*	*The power from the wind*	*Anaerobic digestion*	*Basic thermodynamic functions and applications*	*Mechanical energy storage*
S-3	SLO-1	*Flat plate and dish type*	*Performance of wind mills*	*Direction combustion*	*Calculation of heat of reaction*	*Mechanical energy storage*
	SLO-2	*Types of flat and dish types*	*Modern wind energy generators*	*Pyrolysis*	*Application of Hess law*	*Electrical storage*
S-4	SLO-1	*Solar concentrators*	*Horizontal wind mills*	*Gasification*	*Problems on heat of reaction and Hess law*	*Electrical storage: The lead acid battery*
	SLO-2	*Types of concentrators*	*Vertical wind mills*	*Biogas technology*	*Problems on heat of reaction and Hess law*	*Chemical storage*
S-5	SLO-1	*Solar pumping*	*Wind turbines*	*Bioethanol*	*Other chemical processes for energy transfer*	*Chemical storage*
	SLO-2	*Problems in collectors*	*Design parameters*	*Biodiesel Production*	*Other chemical processes for energy transfer*	*Chemical storage*
S-6	SLO-1	*Solar refrigeration*	*Design principles of wind turbine*	*Community and institutional biogas plants*	*Microwave-assisted reactions*	*Chemical storage*
	SLO-2	*Solar air cooling, Solar furnaces*	*Horizontal and vertical axis types*	*Family biogas plants*	*Microwave-assisted reactions*	*Electromagnetic energy storage*
S-7	SLO-1	*Solar power generation*	*Problems in wind mills*	*Recent Developments in biomass technology*	*Sonochemistry*	*Thermal energy storage (Sensible heat)*
	SLO-2	*Solar drying, stills and cooking*	*Problems in wind mills*	*Energy farming*	*Sonochemistry*	*Thermal energy storage (Sensible heat)*
S-8	SLO-1	*Photo voltaic cell principle*	*Problems in wind mills*	*design consideration*	*Electrochemistry*	*Thermal energy storage (Latent heat)*
	SLO-2	*Photo voltaic cell types*	*Problems in wind mills*	*Problems in digesters*	*Electrochemistry*	*Thermal energy storage (Latent heat)*
S-9	SLO-1	*Photo voltaic cell design*	*Wind power farms*	*Problems in digesters*	*Photochemistry and Photovoltaic Cells*	*Biological storage*
	SLO-2	*Photo voltaic cell advancement*	*Modern wind farms*	*Applications of reactors*	*Photochemistry and Photovoltaic Cells*	*Biological storage*

Learning Resources	1. *Anne E. Marteel-Parrish and Martin A. Abraham, "Green Chemistry and Engineering - A pathway to sustainability", John Wiley & Sons, 2014.* 2. *Rai G.D., "Non Conventional Energy Sources", Khanna Publishers, New Delhi, 1999.*	3. *Bansal N.K, Manfred Kleen Man and Michael Meliss, "Renewable energy sources of conversion technology" TMH Publication.* 4. *Kothari. P., Singal, K. C. and Rakesh, "Renewable Energy Sources and Emerging Technologies", Ranjan PHI Pvt. Ltd., New Delhi, 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
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Course Code	18CHO102T	Course Name	PETROLEUM ENGINEERING	Course Category	O	OPEN ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Chemical 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 (Ioom)	Expected Proficiency %)	Expected Attainment (%)
CLR-1 :	*Understand the formation and evaluation of crude oil, overview of petroleum refining processes, Distillation*			
CLR-2 :	*Understand the Evaluation and testing, properties, Petroleum refining processes*			
CLR-3 :	*Understand the Thermal and catalytic cracking, treatment techniques*			
CLR-4 :	*Understand the production of fuels, lubricating oil, storage and transportation*			
CLR-5 :	*Understand the production of olefin gases, intermediates compounds and important petrochemicals*			
CLR-6:	*Understand the overview of petroleum refinery products*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	1	2	3
		Level of Thinking (Ioom)	Expected Proficiency %)	Expected Attainment (%)
CLO-1 :	*Comprehend the potential growth of petrochemical industries, distillation characteristics*	*1*	*75*	*70*
CLO-2 :	*Comprehend the thermal properties of petroleum fractions*	*1*	*75*	*70*
CLO-3 :	*Comprehend the conversion of petroleum, hydrodesulphurization*	*1*	*80*	*75*
CLO-4 :	*Comprehend the fuel, storage and transportation -characteristics*	*1*	*80*	*75*
CLO-5 :	*Comprehend the flow sheets of important petrochemicals*	*1*	*80*	*75*
CLO-6:	*Comprehend the salient features of petroleum engineering*	*1*	*80*	*70*

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
L		*L*										*H*	*H*	
M		*M*										*H*	*H*	*M*
H		*M*										*H*	*H*	
M		*M*				*L*						*H*	*H*	*M*
M		*H*										*H*	*H*	
H		*H*				*L*						*H*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of petrochemical*	*Distillation condition*	*Octane number*	*Thermal cracking*	*Overview of Refinery Products*
	SLO-2	*Industrial Growth in India, Economics, Feedstock Selection for Petrochemicals*	*Distillation products*	*Cetane number, Diesel index, their determination and importance*	*Thermal cracking in vapor, liquid and mixed phase*	*Refinery Products*
S-2	SLO-1	*Formation*	*Petroleum refining processes*	*Catalytic cracking*	*Production of aviation gasoline*	*Importance and growth potential of petrochemical in India*
	SLO-2	*Formation theories*	*Petroleum Products*	*Houdry fixed bed*	*Properties*	*Petrochemical types*
S-3	SLO-1	*Migration of crude*	*Evaluation of Crude Oil*	*Fluidized bed*	*Motor fuel, kerosene, fuel*	*Reforming and cracking: Cracking of Naphtha*
	SLO-2	*Accumulation of petroleum*	*Testing of Petroleum Products*	*Catalytic bed*	*Diesel oil, tractor fuel and jet*	*Production of C2 and C3 Compounds*
S-4	SLO-1	*Types of crude*	*General processing, topping*	*Reforming process*	*Lubricating oil manufacture*	*Production of intermediate chemicals: Acrylonitrile,*
	SLO-2	*Crude classification*	*vacuum distillations*	*Alkylation process*	*Petroleum waxes and asphalts*	*ethylene oxide*
S-5	SLO-1	*Formation and Evaluation of Crude Oil*	*Physical properties*	*Conversion of petroleum gases into motor fuel with alkylation*	*Storage of petroleum products*	*Higher olefins*
	SLO-2	*General processing of crude*	*Thermal properties*	*Flow diagram*	*Types of storage*	*Benzene*
S-6	SLO-1	*Atmospheric distillation of crude*	*Properties of petroleum fractions*	*Polymerization*	*Tanks*	*Toluene*
	SLO-2	*Flow diagram*	*Thermal properties*	*Hydrogenation and dehydrogenation*	*Bullets*	*Xylene*
S-7	SLO-1	*Distillation condition*	*Flash point, fire point*	*Treatment techniques*	*Special types of spheres*	*Polymerization process*
	SLO-2	*Distillation products*	*Viscosity factor*	*Removal of Sulphur Compounds*	*Transportation of petroleum products, road, rail*	*Plastics*
S-8	SLO-1	*Vacuum distillations*	*Petroleum refining processes*	*Dewaxing*	*Sea and pipeline*	*Ethenic polymers*
	SLO-2	*Flow diagram*		*Clay Treatment and Hydrofining*	*Types of transportation*	*Polyvinyl chloride*
S-9	SLO-1	*Primary process*	*Refining flow diagram*	*Desulphurization,*	*Safety norms*	*Synthetic fibers- polyesters- polyesters ribbon*
	SLO-2	*Secondary process*		*Solvent Treatment Processes*	*Importance of pipeline transportation.*	*Polyethylene Terephthalate*

Learning Resources	1. BhaskaraRao. B.K, "A Text on Petroleum Chemicals", 4thEdn.,Khanna Publishers, New Delhi, 2007 2. Nelson.W.L, "Petroleum Refinery Engineering", McGraw Hill Publishing Company Limited, 1985.	3. GopalaRao M. and Marshall Sittig. "Dryden's Outlines of Chemical Technology", 3rd Edn.,East-West Press, New Delhi, 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 %	

CA – 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. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. K. Anbalagan, SRM Inst. of Science & Technology, anbalagan.k@ktr.srmuniv.ac.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Dr. M.Magesh kumar SRM Inst. of Science & Technology, mageshkumar.m@ktr.srmuniv.ac.in*

Course Code	18CHO103T	Course Name	INTRODUCTION TO CHEMICAL ENGINEERING	Course Category	O	OPEN ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Chemical 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 basics of process calculation*			
CLR-2 :	*Be exposed to the fundamentals of Mechanical Operations*			
CLR-3 :	*Understand the fundamentals of fluid flow phenomena*			
CLR-4 :	*Be exposed to the principles of heat transfer*			
CLR-5 :	*Acquire the knowledge on the basics of mass transfer*			
CLR-6 :	*Be exposed to the basic principles of chemical engineering*			
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Learn the basics of stoichiometry and mass balance*	2	80	70
CLO-2 :	*Familiarized with mechanical operations involved in material handling*	2	80	70
CLO-3 :	*Understand the concept of fluid and its flow*	2	70	65
CLO-4 :	*Gain Knowledge on heat transfer principles*	2	80	70
CLO-5 :	*Comprehend the basics of mass transfer*	2	70	65
CLO-6 :	*Analyze the concepts in chemical engineering*	2	75	65

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*	*L*	
	H	*H*	*L*									*H*	*H*	*L*
	H	*H*	*L*									*H*	*H*	
H	*H*	*H*	*L*									*H*	*H*	
H	*H*		*L*									*M*	*L*	
H	*H*	*H*	*M*									*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Units and dimensions, the mole unit*	*Size reduction*	*Nature of fluids: Type of fluids and flow:*	*Introduction to Heat Transfer*	*Introduction to Mass Transfer operations*
	SLO-2	*mole fraction (or percent) and mass fraction (or percent)*	*Size reduction*	*Nature of fluids: Type of fluids and flow:*	*Various modes of Heat transfer*	*Diffusion, Types, Fick's I law of Diffusion.*
S-2	SLO-1	*analyses of a mixture, concentrations*	*Size analysis*	*incompressible and compressible, potential flow, Laminar and turbulent flow*	*Fourier's law of heat conduction and Thermal conductivity*	*Steady – state molecular diffusion in fluids at rest and in laminar flow: molecular diffusion in gases.*
	SLO-2	*basis of calculations*	*Size analysis*	*incompressible and compressible, potential flow, Laminar and turbulent flow*	*Newton's law of cooling, Natural and forced*	*Molecular diffusion in gases: steady state diffusion of A through non diffusing B*
S-3	SLO-1	*Problem solving on Units and dimensions*	*Screen efficiency*	*Hydrostatic equilibrium and manometers*	*Steady-state conduction compound resistances in series- slab and cylinder.*	*Gas phase equimolal counter diffusion. Diffusion in Multicomponent gas mixtures*
	SLO-2	*Problem solving on Concentrations*	*Screen efficiency*	*Hydrostatic equilibrium and manometers*	*Steady-state conduction compound resistances in series- slab and cylinder.*	*Gas phase equimolal counter diffusion. Diffusion in Multicomponent gas mixtures*
S-4	SLO-1	*predicting P-V-T properties of gases using ideal gas law & Van der Waals equation*	*Filtration and its types – pressure and vacuum filtration*	*Newtonian and Non-Newtonian fluids: Newton's-law of viscosity*	*Steady-state conduction compound resistances in series- slab and cylinder.*	*Molecular diffusion in liquids: steady state diffusion of A through non diffusing B*
	SLO-2	*Calculation of density*	*Filtration and its types – pressure and vacuum filtration*	*Newtonian and Non-Newtonian fluids: Newton's-law of viscosity*	*Steady-state conduction compound resistances in series- slab and cylinder.*	*Molecular diffusion in liquids: steady state diffusion of A through non diffusing B*
S-5	SLO-1	*Basics of chemical equation and stoichiometry*	*Filters and its classification*	*Reynolds number and transition from laminar to turbulent flow*	*Problem solving on heat transfer rate*	*Liquid phase equimolal counter diffusion*
	SLO-2	*limiting reactant, excess reactant, conversion, selectivity and yield*	*Filters and its classification*	*Reynolds number and transition from laminar to turbulent flow*	*Problem solving on heat transfer rate*	*Liquid phase equimolal counter diffusion*
S-6	SLO-1	*Problem solving on Density calculations*	*Basics of Settling and sedimentation*	*Boundary layer concept*	*heat transfer coefficient and Overall heat transfer coefficient*	*Effect of temperature and pressure on diffusivity.*
	SLO-2	*Problem solving on Stoichiometry*	*Basics of Settling and sedimentation*	*Boundary layer concept*	*heat transfer coefficient and Overall heat transfer coefficient*	*Principles of drying, driers and freeze drying*
S-7	SLO-1	*Basic concepts involved in material*	*Principles of agitation, Types of agitators*	*Friction factors*	*Problem solving on heat transfer*	*Various methods of distillation and*

		balance calculations			*coefficient*	*extraction.*
	SLO-2	*Basic concepts of recycle, bypass and purge streams*	*Principles of agitation, Types of agitators*	*Friction factors*	*Problem solving on heat transfer coefficient*	*Various methods of distillation and extraction.*
S-8	SLO-1	*Problem solving on Material Balance - Mixing*	*Flow patterns: prevention of swirling-draft tubes*	*Drag & Lift forces, Terminal settling velocity*	*Heat transfer to fluids without phase change: Boiling and Condensation*	*Basic concept of leaching, adsorption,*
	SLO-2	*Problem solving on Material Balance - Mixing*	*Flow patterns: prevention of swirling-draft tubes*	*Drag & Lift forces, Terminal settling velocity*	*Heat transfer to fluids without phase change: Boiling and Condensation*	*Basic concept of leaching, adsorption,*
S-9	SLO-1	*Problem solving on Material Balance - Drying*	*Blending and Mixing- Mixers: types*	*Introduction to various types of flow metering devices*	*Basic concepts of radiation, examples and application*	*absorption and membrane separation process*
	SLO-2	*Problem solving on Material Balance - Drying*	*Blending and Mixing- Mixers: types*	*Introduction to various types of flow metering devices*	*Basic concepts of radiation, examples and application*	*absorption and membrane separation process*

Learning Resources	1. *David M. Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 6th Edn., Prentice-Hall of India, New Delhi, 1998.* 2. *Anup K Swain, Hemalata Patra, Roy. G.K, "Mechanical operations", Tata -McGraw Hill, 2010.* 3. *Noel de Nevers, "Fluid Mechanics for Chemical Engineers", 3rd Edn., McGraw Hill International Editions, 2011*	4. *Binay K Dutta, "Heat Transfer: Principles and Applications", PHI Learning Private Limited, Delhi,2010* 5. *Christie John Geankoplis, "Transport Processes and Separation Process Principles (Includes Unit Operations)", 4th Edn., Pearson India Education Services Pvt. Ltd., 2015.*

SLO – Session Learning Outcome

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. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. S. Sam David SRM Inst. of Science & Technology, samdavis@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Mr. V. Ganesh SRM Inst. of Science & Technology, ganesv@srmist.edu.in*

Course Code	18CHO104T	Course Name	PROCESS PLANT SAFETY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize the basics of Industrial safety management*
CLR-2 :	*Acquire knowledge on chemical plant safety*
CLR-3 :	*Impart knowledge on Industrial accidents, prevention and fire protection systems*
CLR-4 :	*Acquire knowledge on Hazard identification techniques*
CLR-5 :	*Expose industrial hygiene and Occupational health hazards, Safety legislation in chemical industries*
CLR-6 :	*Learning safety management , chemical plant safety, techniques of hazard identification, Industrial Hygiene, occupational Hazards and safety legislation in chemical industries*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)
CLO-1 :	*Know the basics of Industrial Safety Management.*	*2*	*80*	*70*
CLO-2 :	*Understand the various aspects of Chemical plant safety*	*3*	*80*	*75*
CLO-3 :	*Understand the various aspects of Industrial accidents and Fire safety*	*3*	*80*	*75*
CLO-4 :	*Able to use Hazard identification techniques for the prevention of industrial accidents*	*3*	*85*	*80*
CLO-5 :	*Know the Various aspect of industrial hygiene and Occupational Health hazards, Safety legislation in chemical industries*	*3*	*80*	*75*
CLO-6 :	*Will be able to prevent and control the accidents in chemical Industries by applying the acquired knowledge from Course Learning Rationale*	*1*	*75*	*70*

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

Duration (hour)		9	9	9	9	9
S1	SLO-1	*Importance of Safety consciousness in Indian Chemical Industries*	*Chemical process Industries - Siting and Layout of a Chemical plant*	*Definitions, accident causation theories, Classification, Causes, Costs , Principles of Accident prevention*	*Hazard analysis - Preliminary Hazard Analysis (PHA)*	*Concepts - Industrial and Occupational health hazards, Housekeeping, human factors and error, stress at work*
S2	SLO-1	*Development of Industrial Health and Safety*	*Classification of hazardous chemicals*	*Industrial accidents – Bhopal Gas tragedy, Chernobyl – case study*	*Detailed hazard analysis - FMEA*	*Role of trade unions in Industrial safety and health*
S3	SLO-1	*Development of Industrial Health and Safety - OSHA*	*Transportation of hazardous chemicals*	*Accident prevention technique - Plant and Chemical job safety analysis*	*Fault Tree Analysis*	*Personnel protective equipments –head protection, eye and face protection*
S4	SLO-1	*Safety Organization –Polices-Culture*	*Storage and handling of hazardous chemicals*	*Safety performance measurement tools - FR. SR, (FSI)*	*Hazard and operability (HAZOP) study*	*Personnel protective equipments –hand and foot protection*
S5	SLO-1	*Safety Organization – Planning- Promotion*	*Chemical reaction hazards and their control*	*Safety performance measurement tools- SafeT-Score, Accident rate per 1000 workers*	*Hazard and operability (HAZOP) study*	*Personnel protective equipments –body protection and respirators*
S6	SLO-1	*Safety Organization – Inspection –Rules*	*High pressure - High temperature operations – Case studies*	*Disabling injury index, Accident Compensation Statutes Disabling injury index, Accident Compensation Statutes*	*Human Error Analysis*	*Safety legislation in India, Factories act 1948*
S7	SLO-1	*Safety Organization –Responsibility – Supervision*	*Emergency preparation: On-site and Offsite*	*Accident Investigation reporting and Analysis*	*Risk Analysis*	*Indian boilers act and regulations, Indian electricity act and rules*
S8	SLO-1	*Effective Safety Education and Training*	*Safe guarding of Machines – Ergonomics*	*Conditions -Fire triangle- Classification of fires*	*Risk assessment*	*Indian explosives act and rules, Mines act, Petroleum act and rules*
S9	SLO-1	*Communication at various levels of production and operation, Safety slogans*	*Safe guarding of Machines – Ergonomics*	*Common causes of industrial fires, Fire protection systems- prevention*	*Dow (Index) Fire and Explosion Index*	*Environmental protection act.*

Learning	*1. Sharma. A M "Safety and Health in Industry" -A Hand book, BS Publications , 2009*	*4. Willie Hammer &Dennis Price, Occupational safety management and Engineering, Prentice Hall, 2001*

Resources	2. *Fulekar. M.H, "Industrial Hygiene and Chemical Safety", I.K International Publishing house Pvt Ltd., 2006.* 3. *Fawcett .H.H, and Wood .W.S, Safety and Accident Prevention in Chemical Operations, John Wiley & sons, U.S.A.,1965*	5. *William Handley, Industrial safety hand book, McGraw- Hill, 1969 6. Daniel. A, Crowl& Joseph. F Louvar Chemical Process safety: fundamentals with applications, Prentice Hall international series*

SLO – Session Learning Outcome

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 %	

CA – 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. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,*	1. *Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*Dr.B.Karunanithi* *SRM Institute of Science and Technology* *karunanb@srmist.edu.in*
2. *Mr. S. T. Kalaimani, CPCL, Chennai*	2. *Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*Ms.D.Nanditha* *SRM Institute of Science and Technology* *nandithd@srmist.edu.in*

Course Code	18CHO105T	Course Name	POLLUTION ABATEMENT	Course Category	O	OPEN ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*know about the industrial activities and fates of industrial contaminants*
CLR-2 :	*know about the environmental regulations*
CLR-3 :	*know about the air pollution control methods*
CLR-4 :	*know about the principles of water treatment*
CLR-5 :	*know about the air pollution control methods*
CLR-6:	*know about the sources and treatment options for environmental issues*

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 major industries that creates pollutants and how it affects the environment*	*1*	*85*	*75*
CLO-2 :	*Implement the rules and regulations in specific industries*	*1*	*75*	*70*
CLO-3 :	*Identify the sources of air pollution and able to control the air pollution*	*1*	*85*	*75*
CLO-4 :	*Identify different water treatment methods used in industry and able to implement the methods wherever necessary*	*1*	*85*	*75*
CLO-5 :	*Identify the sources of air pollution and able to control the air pollution*	*1*	*85*	*75*
CLO-6 :	*Identify the pollution nature and able to bring the solution*	*1*	*75*	*70*

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	PSO1	PSO2	PSO3
	L		*L*		*H*	*H*		*M*			*H*	*H*	*L*	*L*
	H		*H*	*L*		*H*	*M*	*M*				*H*	*L*	*L*
M	*M*	*H*	*M*			*L*					*H*	*M*	*H*	*H*
H	*H*	*M*	*M*			*M*	*M*	*L*			*H*	*M*	*H*	*H*
H	*H*	*M*	*M*			*M*	*M*	*L*			*H*	*M*	*H*	*H*
H	*H*	*M*	*M*			*M*	*M*	*L*			*H*	*M*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*introduction*	*environmental regulations prevention vs control of industrial pollution.*	*air pollution control methods introduction to particulate emission control*	*principles of water treatment primary, secondary and tertiary treatments*	*solid waste and disposal methods sources and types of solid waste*
	SLO-2	*introduction*	*prevention vs control of industrial pollution*	*gravitational settling chambers*	*principles of water treatment secondary treatments*	*sources and types of solid waste*
S-2	SLO-1	*industrial activity and environment*	*prevention vs control of industrial pollution*	*cyclone separators,*	*principles of water treatment secondary treatments*	*processing methods, disposal- principle, practices and methods,*
	SLO-2	*industrial activity and environment*	*prevention vs control of industrial pollution*	*electrostatic precipitators*	*principles of water treatment secondary treatments*	*processing methods, disposal- principle, practices and methods,*
S-3	SLO-1	*industrial activity and environment*	*prevention vs control of industrial pollution*	*Volatile organic compounds control*	*principles of water treatment tertiary treatments*	*processing methods, disposal- principle, practices and methods,*
	SLO-2	*industrial activity and environment*	*prevention vs control of industrial pollution*	*Volatile organic compounds control*	*principles of water treatment tertiary treatments*	*processing methods, disposal- principle, practices and methods,*
S-4	SLO-1	*fates of industrial contaminants*	*environment policies and regulations to encourage pollution prevention*	*Volatile organic compounds control*	*principles of water treatment tertiary treatments*	*energy from solid waste, waste management hierarchy,*
	SLO-2	*fates of industrial contaminants*	*environment policies and regulations to encourage pollution prevention*	*control of sulphur dioxide*	*principles of water treatment tertiary treatments*	*energy from solid waste, waste management hierarchy,*
S-5	SLO-1	*case studies on industrial contaminants*	*environment policies and regulations to encourage pollution prevention*	*control of sulphur dioxide*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
	SLO-2	*case studies on industrial contaminants*	*environment policies and regulations to encourage pollution prevention*	*control of sulphur dioxide*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
S-6	SLO-1	*industrialization and sustainable development*	*environment friendly chemical processes*	*control of oxides of nitrogen*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
	SLO-2	*industrialization and sustainable development*	*environment friendly chemical processes*	*control of oxides of nitrogen*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
S-7	SLO-1	*sustainability strategies*	*environment friendly chemical processes*	*control of carbon monoxide and hydrocarbons*	*advanced waste water treatments*	*energy from solid waste, waste management hierarchy,*
	SLO-2	*sustainability strategies*	*environment friendly chemical processes*	*control of carbon monoxide and*	*advanced waste water treatments*	*energy from solid waste, waste*

				hydrocarbons		*management hierarchy,*
S-8	SLO-1	*barriers to sustainability*	*regulations for clean environment and implication for industries*	*noise pollution measurements and its control*	*recovery of metals from process effluents*	*energy from solid waste, waste management hierarchy,*
	SLO-2	*Barriers to sustainability*	*Regulations for clean environment and implication for industries*	*Noise pollution measurements and its control*	*Recovery of metals from process effluents*	*energy from solid waste, waste management hierarchy,*
S-9	SLO-1	*Pollution prevention in achieving sustainability*	*Regulations for clean environment and implication for industries*	*Noise pollution measurements and its control*	*Recovery of metals from process effluents*	*hazardous waste, biomedical waste, and nuclear waste.*
	SLO-2	*Pollution prevention in achieving sustainability*	*Regulations for clean environment and implication for industries*	*Noise pollution measurements and its control*	*Recovery of metals from process effluents*	*hazardous waste, biomedical waste, and nuclear waste.*

Learning Resources	*1. Bishop.P, "Pollution Prevention: Fundamentals and Practice", McGraw Hill International Edn., McGraw Hill Book Co., Singapore, 2000* *2. Freeman.H.M, "Industrial Pollution Prevention Hand Book", McGraw Hill, 1995* *3. James. G. Mann and Liu.Y.A, "Industrial Water Reuse and Waste Water Minimization", McGraw Hill, 1999*	*4. Rose.G.R.D, "Air pollution and Industry", Van Nostrand Reinhold Co., NewYork 1972* *5. Pandey.G.N and Carney.G.C, "Environmental Engineering", Tata McGraw Hill, New Delhi,1989* *6. Kapoor.B.S, "Environmental Engineering", 3rd Edn., Khanna publishers,1997*

SLO – Session Learning Outcome

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 %	

CA –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. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*1 Dr. B.Karunanithi SRM Inst. of Science & Technology, karunab@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	*2 Dr. S.Vishali SRM Inst. of Science & Technology, vishalis@srmist.edu.in*

Course Code	18CHO106T	Course Name	INTRODUCTION TO PROTEOMICS	Course Category	O	OPEN ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce protein structure and function*
CLR-2 :	*Understand the methodologies utilized for protein isolation*
CLR-3 :	*Understand the analytical methodologies available for protein identification*
CLR-4 :	*Have an insight into methods available for the identification of proteins in a high-through-put manner*
CLR-5 :	*Apply a scientific approach to proteomics investigation using bioinformatics tools*
CLR-6 :	*Introduce various combination of sample preparation and analytical methodologies for proteomics investigation*

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 :	*Understand the significance of protein structure and function from a physiological context*	*2*	*80*	*70*
CLO-2 :	*Design a sequence of methodologies for desired protein isolation from complex matrices*	*3*	*80*	*75*
CLO-3 :	*Design one or more analytical methodologies in series or parallel for protein identification*	*3*	*80*	*75*
CLO-4 :	*Conceive high-throughput screening methodology for identification of proteins in complex mixtures*	*3*	*85*	*80*
CLO-5 :	*Utilize proteomics methodologies aided by bioinformatics tools for protein characterization*	*3*	*80*	*75*
CLO-6 :	*Design a sample preparation and analytical methodology scheme for a proteomics investigation*	*1*	*75*	*70*

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
L	*M*	*M*	*M*	*L*							*M*	*H*	*M*	*M*
L	*M*	*M*	*M*	*M*							*M*	*H*	*M*	*M*
L	*M*	*M*	*M*	*H*							*M*	*H*	*M*	*M*
L	*M*	*M*	*M*	*H*	*L*	*L*					*M*	*H*	*M*	*M*
L	*M*	*H*	*H*	*H*	*L*	*L*	*L*	*M*	*M*		*H*	*H*	*H*	*H*
M	*H*	*H*	*H*	*H*	*L*	*L*	*L*	*H*	*H*		*H*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S1	SLO-1	*An Overview of Proteomics*	*Strategies for Protein Identification*	*MS- principles*	*Protein structures*	*Protein Chips and Functional Proteomics*
S2	SLO-1	*Need, scope and challenges of proteomics*	*Strategies for Protein Identification*	*MS- principles*	*Techniques for solving protein structures*	*Protein Chips and Functional Proteomics*
S3	SLO-1	*Strategies for Protein separation*	*Strategies for Protein Identification*	*Instrumentation and applications in proteomics*	*Techniques for solving protein structures*	*Protein Chips and Functional Proteomics*
S4	SLO-1	*2D gel electrophoresis- principle and applications*	*Protein Identification with antibodies*	*Instrumentation and applications in proteomics*	*Techniques for solving protein structures*	*Applications of Proteomics in disease diagnosis*
S5	SLO-1	*2D gel electrophoresis- principle and applications*	*Protein Identification with antibodies*	*Strategies for Protein Quantization*	*Protein interactions- principles and methods to study them*	*Applications of Proteomics in disease diagnosis*
S6	SLO-1	*Liquid chromatography- principle and applications*	*Protein Identification with antibodies*	*Quantitative proteomics with standard 2D gels Multiplexed proteomics*	*Protein interactions- principles and methods to study them*	*Applications of Proteomics in disease diagnosis*
S7	SLO-1	*Liquid chromatography- principle and applications*	*Protein sequence determination by chemical degradation*	*Quantitative proteomics with standard 2D gels Multiplexed proteomics*	*Protein interactions- principles and methods to study them*	*Drug development and plant biotechnology*
S8	SLO-1	*Multidimensional liquid chromatography*	*Protein sequence determination by chemical degradation*	*Quantitative with mass spectrometry*	*Protein Modification in Proteomics.*	*Drug development and plant biotechnology*
S9	SLO-1	*Multidimensional liquid chromatography*	*Protein sequence determination by chemical degradation*	*Quantitative with mass spectrometry*	*Protein Modification in Proteomics.*	*Drug development and plant biotechnology*

Learning Resources	
	1. R. M. Twyman, Principles of Proteomics (Advanced Text Series), Bios Scientific, 2004
	2. David W Mount, Bioinformatics- Sequence and genome analysis, Cold Spring Harbor Laboratory Press, second edition, 2004.
	3. S. R. Pennington, M. J. Dunn, Proteomics: from Protein Sequence to Function, Springer publications, first edition, 2001.
	4. Timothy Palzkill, Proteomics, Springer, 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 %	

CA – 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. A. Subramaniam, PESCO Beam Environmental Solutions Pvt. Ltd.,	*1. Dr. Lima Rose Miranda, Anna University, email: limamiranda2007@gmail.com*	*Dr. M.P. Rajesh* *SRM Institute of Science and Technology* *rajeshm@srmist.edu.in*
2. Mr. S. T. Kalaimani, CPCL, Chennai	*2. Dr. T. R. Sundararaman, Rajalakshmi Engineering College*	

Course Code	18CEO301T	Course Name	ADVANCED DESIGN OF RCC	Course Category	O	Open Elective Courses	L	T	P	C
							2	1	0	3

Pre-requisite Courses	18CEC207T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	IS 456-2000, SP 16 Charts, IS 3370 Part1,2,3,4, IS 1343-2012, IRC 3-1983, IRC:83-2018 (Part II)		

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 :	*Analyse the retaining wall with the effect of active and passive pressure*			
CLR-2 :	*Design of Flat Slab using Direct Design Method as per IS456-2000*			
CLR-3 :	*Utilize the concept the of yield line theory*			
CLR-4 :	*Design Water Tanks using Working Stress Method*			
CLR-5 :	*Utilize concepts of ILD to analyse the RCC bridge for simple spans*			
CLR-6 :	*Analyse prestressed concrete sections for flexure*			

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 effect of active and passive pressure influencing the behavior in design of retaining walls*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-2 :	*Analyse the behavior of Flat slab in flexure and punching shear*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-3 :	*Apply yield line theory to the design of slabs*	*3*	*75*	*75*	*H*	*H*	-	*H*	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-4 :	*Analyse the behavior of underground and elevated water tanks*	*3*	*90*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*M*
CLO-5 :	*Analyseand design of RCC Bridge and Culvert using IRC loadings*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*M*
CLO-6 :	*Apply the strength and load balancing concept to the design of beams in flexure*	*3*	*80*	*75*	*H*	*H*	-	*H*	-	-	-	-	-	-	-	-	*H*	-	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*RETAINING WALLS Introduction to Retaining Walls*	*FLAT SLABS Introduction to Flat Slab*	*RCC WATER TANKS Introduction to Water Retaining Structures*	*DESIGN OF BRIDGES Types of bridges and culverts*	*PRESTRESSED CONCRETE STRUCTURES Basic concepts*
	SLO-2	*Design of Retaining Walls, Proportioning of the size of the wall*	*Advantages of Flat Slab*	*Design of Rectangular and Circular Water Tanks*	*Simply supported girder bridges, Balanced cantilever and their behavior*	*Principle of prestressing methods and materials required*
S-2	SLO-1	*Design for Overturning moment*	*Design of Flat slab, Proportioning*	*Design Problems – Circular slabs subjected to direct tension*	*Design Problems*	*Stress and Strength concept and Load balancing concept*
	SLO-2	*Design for Sliding and provision for shear key*	*Design for Bending*	*Design Problems – Contd.,*	*Introduction to IRC Loading, impact loading, Codal Provisions for design*	*Design Problems*
S-3	SLO-1	*Tutorials*	*Tutorials*	*Tutorials*	*Tutorials*	*Tutorials*
	SLO-2	*Tutorials*	*Tutorials*	*Tutorials*	*Tutorials*	*Tutorials*
S-4	SLO-1	*Design of Toe and Heel Slab of Retaining Wall*	*Thickness of flat slab based on punching shear*	*Design Problems*	*Design of slab culvert for Class AA, 70R, Class A*	*Analysis of sections subjected to flexure*
	SLO-2	*Design of Stem of Retaining Wall*	*Design Problems*	*Design of Underground Water Tanks*	*Design Problems – Design of slabs based on IRC Codes*	*Design Problems – Beams subjected to eccentric prestressing*
S-5	SLO-1	*Introduction to Counterfort Retaining Walls*	*INTRODUCTION TO YIELD LINE THEORY*	*Design Problems – Design of Rectangular Water tanks (L/B >2)*	*Design Problems – Contd.,*	*Design Problems – Contd.,*
	SLO-2	*Design of Counterfort Retaining Walls, Proportioning of the size of the wall and Counterfort*	*Design of Square and Rectangular Slabs*	*Design Problems*	*Design Problems*	*Losses of prestress using Simple cable profile*
S-6	SLO-1	*Tutorials*	*Tutorials - Design of Square slabs for simply supported condition*	*Tutorials - Design of Rectangular Water tanks (L/B < 2)*	*Tutorials*	*Tutorials – Losses due to elastic deformation of concrete*
	SLO-2	*Tutorials*	*Tutorials – Contd.,*	*Tutorials*	*Tutorials*	*Tutorials – Contd.,*

S-7	SLO-1	*Design for Overturning moment*	*Design of Square slabs for fixed support condition*	*Design of overhead water tank and Intze type tanks*	*Loads on T-beam girder bridges using Courbans theory*	*Design of beams subjected to losses in shrinkage in concrete*
	SLO-2	*Design for Sliding and provision for shear key*	*Check for bending and shear*	*Design Problems*	*Design Problems*	*Design Problems – Contd.,*
S-8	SLO-1	*Design of Toe and Heel Slab of Counterfort Retaining Wall*	*Design of Circular and Triangular Slabs*	*Design of Staging with columns and beams, Shaft and conventional types*	*Drawing ILD diagram for simple spans and calculation of design Bending moment, shear force for class AA and class A loading*	*Introduction to design of beams*
	SLO-2	*Design of Stem of Counterfort Retaining Wall*	*Design of Circular and Triangular Slabs*	*Design Problems*	*Design Problems*	*Design of beams based on IS 1343.*
S-9	SLO-1	*Tutorials*	*Tutorials - Design of triangular slabs for different edge conditions*	*Tutorials*	*Tutorials*	*Tutorials*
	SLO-2	*Tutorials*	*Tutorials – Contd.,*	*Tutorials*	*Tutorials*	*Tutorials*

Learning Resources	1. *Krishnaraju.N, Pranesh.R.N, Reinforced Concrete Design, New Age International Publication, 2003.* 2. *Ramamrutham.S, Design of Reinforced Concrete Structures, DhanpatRai Publishing Company., 2015.* 3. *Johnson Victor D, Essentials of Bridge Engineering, 4th ed, Oxford & IBH Publishing Company, 2007.* 4. *UnnikrishnaPillai.S, DevdasMenon, Reinforced Concrete Design, 5thed., Tata McGraw, 2003.*	5. *Subramanian.N, Design of Reinforced Concrete Structures, Oxford University Press, 2013* 6. *Krishnaraju.N, Prestressed Concrete, Tata McGraw-Hill Education, 2008* 7. *NPTEL Course: Reinforced Concrete Road Bridges.https://onlinecourses-archive.nptel.ac.in/noc17_ce24/preview* 8. *NPTEL Course: Prestressed Concrete Structures https://nptel.ac.in/courses/105106117*

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. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*1. Dr. R. Santhakumar, Professor, Centre for Rural Department, NITTTR*	*Prof. G. Augustine ManirajPandian, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*Dr.P.R.Kannan Rajkumar, SRMIST*

Course Code	18CEO302J	Course Name	MODERN CIVIL ENGINEERING ECONOMICS	Course Category	O	Open Elective Course	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
CLR-1 :	*Understand the basic principles of economies*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	*Realize the type of firm and market structure*			
CLR-3 :	*Understand the concept of Indian economy*			
CLR-4 :	*Apply the concept of estimation*			
CLR-5 :	*Realize the types of construction specification*			
CLR-6 :	*Analyze rate analysis*			

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 various economic policies*	*3*	*85*	*75*	*H*	*H*	-	-	-	*H*	-	-	-	-	-	-	*H*	-	-
CLO-2 :	*Identify the forms of market structure and organization*	*2*	*85*	*75*	*H*	*H*	-	-	-	*H*	-	-	-	-	-	-	*H*	-	-
CLO-3 :	*Apply the concepts of time value of money*	*2*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	-	*H*	-	-
CLO-4 :	*Determine the different types of estimation*	*2*	*85*	*75*	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	*H*	-	-
CLO-5 :	*Develop the specification for different types of buildings*	*3*	*85*	*75*	*H*	*H*	-	*M*	-	-	-	-	*H*	-	-	-	*H*	-	-
CLO-6 :	*Identify the factors affecting rate analysis*	*3*	*85*	*75*	*H*	*H*	-	*M*	-	-	-	-	*H*	-	-	-	*H*	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic Principles and Methodology of Economics.*	*Forms of organizations*	*ROI Problem*	*Present and future worth of cash flows*	*Rate analysis-Importance*
	SLO-2	*Demand/supply*	*Cost & Cost Control –Techniques*	*Payback Period*		*Rate analysis-necessity*
S-2	SLO-1	*Government Policies and Application*	*Types of Costs*	*Payback Period Problem*	*Structure of productive activity*	*Factors affecting rate analysis*
	SLO-2	*Basic Macro-economic Concepts*	*Lifecycle costs*	*Bid price*	*Urbanization*	*Equipment productivity*
S-3	SLO-1	*Drawings to read and understand - Autocad*	*Earthwork estimation (Foundation)*	*Estimation of finishes (Interior and Exterior)*	*Estimation of MEP works*	*Rate analysis – Concrete works*
	SLO-2					
S-4	SLO-1	*Drawings to read and understand - Autocad*	*Earthwork estimation (Foundation)*	*Estimation of finishes (Interior and Exterior)*	*Estimation of MEP works*	*Rate analysis – Concrete works*
	SLO-2					
S-5	SLO-1	*GDP/GNP/NI/Disposable income*	*Break even Analysis*	*Evaluation of bids*	*Indian economy - plans*	*Labour productivity*
	SLO-2	*Public sector economics –welfare*			*Post reform Growth*	*Factors affecting productivity*
S-6	SLO-1	*Public sector economics – externalities, labour market*	*Budgets*	*RA Bills*	*Specifications-Types, requirements and importance*	*Measurements for various items*
	SLO-2	*Components of Monetary and Financial System*	*Capital Budgeting*		*detailed specifications for buildings*	*Introduction to the process of Estimation*
S-7	SLO-1	*Quantity estimation basics - Excel*	*Estimation of concrete works (Sub and super structure)*	*Estimation of bridges*	*Reinforcement calculations*	*Rate analysis – Masonry works*
	SLO-2					
S-8	SLO-1	*Earthwork estimation (Embankments & Trenches)*	*Estimation of masonry works*	*Estimation of culverts*	*BIM Quantity Takeoff*	*Rate analysis - Plastering*
	SLO-2					
S-9	SLO-1	*Central bank –monetary aggregates, Commercial banks & their functions*	*Application of Linear Programming*	*Final bills*	*Detailed specifications for roads, Detailed specifications for minor bridges*	*IS standards for quantity estimation, IS standards for quantity estimation - recommendations*
	SLO-2	*Capital and Debt Markets, Elements of Business/Managerial Economics*	*Investment Analysis – NPV Problem*	*Depreciation and Time value of money*	*Detailed specifications for industrial structures, Rate analysis-Purpose*	*Drawings – Architectural, Drawings – Structural and MEP*

Learning Resources	1. *Mankiw Gregory N. (2002), Principles of Economics, Thompson Asia* 2. *V. Mote, S. Paul, G. Gupta(2004), Managerial Economics, Tata McGraw Hill* 3. *Misra, S.K. and Puri (2009), Indian Economy, Himalaya* 4. *Pareek Saroj (2003), Textbook of Business Economics, Sunrise Publishers* 5. *Typical PWD Rate Analysis documents.*	6. *Dutta, B.N., Estimating and Costing in Civil Engineering (Theory & Practice), UBS Publishers, 2016* 7. *Dutta, B.N., Estimating and Costing in Civil Engineering (Theory & Practice), UBS Publishers, 2016* 8. *Introduction to Accounting and Finance for Civil Engineers – NPTEL Online course*

Learning Assessment											
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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 %	

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Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Rajeev Srinivasan, Senior Planning, NASS Contacting, Rajeev.srinivasan@nasscontracting.com	*Dr. A .R. Krishnaraja, Associate professor, Kongu Engineering college, krajacivil@kongu.ac.in*	*Mr.M.B.Sridhar, Asst. Prof., SRMIST*
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Course Code	18CEO303J	Course Name	MODERN TOOLS IN ENGINEERING SURVEYING	Course Category	O	Open Elective Course	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18CEC204T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	CIVIL ENGINEERING	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Determine the Horizontal and vertical control*
CLR-2 :	*Know the Hydrographic surveying*
CLR-3 :	*Understand Advance surveying instruments*
CLR-4 :	*Know Global positioning System and segments*
CLR-5 :	*Introduce photogrammetry to civil engineering*
CLR-6 :	*Introduction of remote sensing to civil engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*know the basics, importance, and methods of Triangulation and Trilateration*	2	85	80	H	-	-	-	-	-	M	-	L	-	-	H	H	-	-
CLO-2 :	*Study the various Hydrographic Surveying Techniques.*	2	85	75	H	-	-	-	-	-	M	-	L	-	-	H	H	-	-
CLO-3 :	*Acquire knowledge about EDM and Total Station*	2	80	75	H	-	-	-	-	-	H	-	L	-	-	H	H	-	-
CLO-4 :	*Survey Using GPS.*	2	85	80	H	-	-	-	-	-	H	-	L	-	-	H	H	-	-
CLO-5 :	*Study the Concept of Aerial Photo Interpretation.*	2	85	75	H	H	H	M	H	-	H	-	M	-	-	H	H	-	-
CLO-6 :	*learn the importance and different aspects of remote sensing*	2	80	75	H	H	H	H	H	-	H	-	M	-	-	H	H	-	-

Duration (hour)		09	09	09	09	09
S-1	SLO-1	*TRIANGULATION AND TRILATERATION*	*HYDROGRAPHIC SURVEYING*	*EDM, TOTAL STATION, GPS SURVEYING*	*PHOTOGRAMMETRY SURVEYING*	*REMOTE SENSING*
	SLO-2	*Horizontal Vertical control - methods Triangulation – Primary Secondary and Tertiary Triangulation*	*Methods of Hydrographic Surveying Establishment of Horizontal control Tide Gauges-*	*Infrared EDM & Microwave system-Measuring DDM-ODM- EDM Electro-optical system- Measuring& Working Principle,*	*Introduction - Photogrammetry in Civil engineering History of Photogrammetry ,*	*Introduction , Historical Background Components of Remote sensing*
S-2	SLO-1	*Base line –Figure and Layout of base lines*	*Recording and non recording Type, Staff, float and weight gauge, Self registering Tide Gauge*	*Sources of error in EDM ,Total station-Types*	*Terminology in Photogrammetry- Photo theodolite,*	*Electromagnetic Radiation (EMR) Ideal remote sensing system*
	SLO-2	*Base line extension- By Prolongation By Double Sigjhting Method*	*Equipments of Sounding-Shore signal and buoys*	*Measuring and working principle,*	*Terrestrial and Aerial photographs - vertical and oblique photograph*	*Wave length and Frequency of Different bands*
S-3	SLO-1	*Tacheometric Surveying--Constants of Tacheometer*	*Setting out simple circular curve --Single Theodolite Method*	*Total Station Surveying - Measurements of Distances and angles,*	*Total Station Surveying - Measurements of Traversing,*	*Identification of aerial photographs*
	SLO-2	*Tacheometric Surveying--Constants of Tacheometer*	*Setting out simple circular curve --Single Theodolite Method*	*Total Station Surveying - Measurements of Distances and angles,*	*Total Station Surveying - Measurements of Traversing,*	*Identification of aerial photographs*
S-4	SLO-1	*Tacheometric Surveying--Stadia Tacheometry*	*Setting out simple circular curve --Double Theodolite Method*	*Total Station Surveying- Measurements of, Slope*	*GPS Surveying –Measurement of Coordinates*	*Aerial Photo Interpretation Using Photo Interpretation Keys*
	SLO-2	*Tacheometric Surveying--Stadia Tacheometry*	*Setting out simple circular curve --Double Theodolite Method*	*Total Station Surveying- Measurements of, Slope*	*GPS Surveying –Measurement of Coordinates*	*Aerial Photo Interpretation Using Photo Interpretation Keys*
S-5	SLO-1	*Baseline measurement- instruments and accessories Wheelers baseline apparatus*	*Sounding Equipment, Angle measuring instruments Location of Sounding-*	*Coordinate system-Classification, GPS - Fundamentals*	*Scale of an aerial photograph Types of scales*	*Interactions with atmosphere & Earth features*
	SLO-2	*Jardein's Method & Hunter's short base Method*	*Observation from the shore , boat, both shore and boat*	*Space ,Control & User Segments of GPS*	*Overlapping of Aerial Photographs,*	*Platform, Sensors Definition, Types Airborne Platforms*

S6	SLO-1	*Correction Determination of intervisibility of triangulation stations*	*Location by stretched wire across a river*	*Errors in GPS Surveying*	*Measurement of Scale, Flight Planning,*	*Geostationary and Sunsynchronuous Orbits*
	SLO-2	*Axial Signal Correction-Eye and Object Correction*	*Plotting of Sounding - Mechanical method ,*	*GPS Surveying Methods*	*Photo interpretation keys*	*Active and passive remote sensing*
S-7	SLO-1	*Tacheometric Surveying--Tangential Tacheometer*	*Setting out simple circular curve --Single Theodolite Method*	*Total Station Surveying- Measurements of distances &Height*	*Use of Stereoscope for 3-D Viewing*	*Tracing of Landuse and land cover from image*
	SLO-2	*Tacheometric Surveying--Tangential Tacheometer*	*Setting out simple circular curve --Single Theodolite Method*	*Total Station Surveying- Measurements of distances &Height*	*Use of Stereoscope for 3-D Viewing*	*Tracing of Landuse and land cover from image*
S-8	SLO-1	*Tacheometric Surveying--Subtense bar method*	*Contouring*	*Total Station Surveying - Measurements of Traversing,*	*Height determination from a Stereo pair using the Parallax bar*	*Tracing of Landuse and land cover from image*
	SLO-2	*Tacheometric Surveying--Subtense bar method*	*Contouring*	*Total Station Surveying - Measurements of Traversing,*	*Height determination from a Stereo pair using the Parallax bar*	*Tracing of Landuse and land cover from image*
S-9	SLO-1	*Satellite Station Reduction to Centre*	*Graphical Method ,Analytical Method Stream Gauge-Area velocity Method*	*Kinematic Surveying*	*Stereoscopy-Stereoscope and Stereo-photographs*	*Spectral –Radiometric &Temporal resolution Microwave remote sensing*
	SLO-2	*Signals –Luminous and Non-luminous Signals Towers*	*Velocity Measurement using Floats &Current meter Weir method, Chemical Method*	*Static Surveying*	*Photo interpretation keys, Applications of aerial Photos*	*Scanners - Radiometer - RADAR, Applications of Remote Sensing*

Learning Resources	*1. Kanetkar .T.P, "Surveying and Levelling" Vols. I and II, United Book Corporation, Pune, 1994.* *2. Surveying and leveling Part I"I, Late T P Kanetkar and Prof. S V Kulkarni, Poona VidyagrihaPrakashan,* *3. Punmia .B.C, "Surveying, Vols". I and II, Laxmi Publications,1999.*	*https://nptel.ac.in/noc/individual_course.php?id=noc18-ce37* *https://swayam.gov.in/nd1_noc19_ce39* *https://swayam.gov.in/nd1_noc19_ce34* *https://nptel.ac.in/noc/individual_course.php?id=noc18-ce35 (Part I and II)*

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	*15%*	*15%*	*15%*	*15%*	*20%*	*20%*	*20%*	*20%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*15%*	*15%*	*15%*	*15%*	*10%*	*10%*	*10%*	*10%*	*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 G Hariharanath, Chief Executive ,GA consultants,gac1996@hotmail.com	*Dr. E S M. Suresh, NITTR,esmsuresh@gmail.com*	*Dr. Sachikanta Nanda, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*Dr. Srinivasa Raju, IRS, Anna University, raju_irs@yahoo.com*	*Dr. R. Annadurai, SRMIST*

Course Code	18CEO304T	Course Name	EMERGING TRENDS IN STEEL DESIGN	Course Category	E	Open Elective Course	L	T	P	C
							2	1	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards	IS : 800-2007, Steel Tables(Revised), IS : 875-Part 1,2 & 3		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
CLR-1 :	*Identify the characteristics of steel connection types and different configurations*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	*Identifying structural steel connections and appropriate design*			
CLR-3 :	*Identify and solve beam-column design, plate and gantry girder*			
CLR-4 :	*Solve the basic column base problems and to design the base plates*			
CLR-5 :	*Analyze the basic concepts roof types and to design connections for different roof models*			
CLR-6 :	*Identify pre-engineered building components, classification of towers and loading combinations*			

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 :	*Accrue the knowledge of steel connections, beam-column joints and plates*	2	85	75	H	M	M	L	-	-	-	-	L	-	-	M	L	-	-
CLO-2 :	*Analyze and Design eccentric and moment resistant connections*	2	85	75	H	H	M	M	-	-	-	-	L	-	-	M	L	-	-
CLO-3 :	*Analyze and Design beam-columns, plate girder and gantry girder*	2	85	75	H	H	M	M	-	-	-	-	-	-	-	M	-	-	-
CLO-4 :	*Accrue the knowledge on Design of column bases and eccentrically loaded base plate*	2	85	75	H	H	M	M	-	-	-	-	L	-	-	M	L	-	-
CLO-5 :	*Analyze and design roof truss and connections of industrial structures*	2	85	75	H	H	M	M	-	-	-	-	-	-	-	M	-	-	-
CLO-6 :	*Accrue comprehensive knowledge in Understanding design principle of pre-engineered buildings and towers*	2	85	75	H	H	M	M	-	-	-	-	L	-	-	M	L	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Steel Design*	*Introduction to Beam-Column*	*Introduction to column bases*	*Structural frames and functions of components*	*Components of pre-engineered buildings*
	SLO-2	*Brief notes on emerging trends in structural steel design*	*Beam-Column configuration*	*Introduction to footing*	*Types of roof trusses for different spans*	*Structural behavior of pre-engineered buildings*
S-2	SLO-1	*Connection types*	*Behaviour of short beam-columns*	*Types of footings*	*Estimation of dead loads, live loads, wind loads*	*Pre-engineered buildings – Design aspects*
	SLO-2	*Connection configuration*	*Behaviour of long beam-columns*	*Design of Slabs*	*Load combinations*	*Pre-engineered buildings – Design aspects*
S-3	SLO-1	*Simple connections*	*Numerical problems on beam-column*	*Design of Slabs – Numerical problems*	*Analysis of roof truss - Principles*	*Connection design - Concept*
	SLO-2	*Simple connection configuration*	*Numerical problems on beam-column*	*Design of Slabs – Numerical problems*	*Analysis of roof truss*	*Connection design*
S-4	SLO-1	*Tutorial 1: Connections*	*Tutorial 3: Beam-Column design*	*Tutorial 5: Column bases, footings and slabs*	*Tutorial 7: Roof truss and load*	*Tutorial 9: Pre-engineered buildings components and connections*
	SLO-2					
S-5	SLO-1	*Semi-rigid connections*	*Interaction Formula*	*Design of gusseted plate*	*Design of roof truss - Concept*	*Introduction to Plate grider*
	SLO-2	*Semi-rigid connection configurations*	*Principles of Beam-Column*	*Numerical problems on gusseted plate*	*Design of roof truss*	*Components of a plate girder*
S-6	SLO-1	*Rigid Connections*	*Design approach to beam-column*	*Numerical problems on gusseted plate*	*Numerical problems on roof truss design*	*Various sections adopted for plate girders*
	SLO-2	*Rigid connection configurations*	*Design consideration*	*Design of base plate and connections*	*Numerical problems on roof truss design*	*Variations in girder section*
S-7	SLO-1	*Numerical problems on Simple configuration*	*Boundary constraints and restraints*	*Design of base plate and connections – Numerical problems*	*Design of Purlins - Concept*	*Design concept of plate girder*

	SLO-2	*Numerical problems on Simple configuration*	*Introduction to gantry girder*	*Design of base plate and connections – Numerical problems*	*Design of purlins*	*Design of plate girder*
S-8	SLO-1	*Tutorial 2: Connection numerical problems and applications*	*Tutorial 4: Gantry girder*	*Tutorial 6:Plates and connections*	*Tutorial 8: Roof truss and Purlins*	*Tutorial 10: Plate girder*
	SLO-2					
S-9	SLO-1	*Numerical problems on Semi-rigid and rigid configuration*	*Gantry girder - Principles*	*Design applications of gusseted plates*	*Numerical problems on purlins*	*Plate girder - Principles*
	SLO-2	*Numerical problems on Semi-rigid and rigid configuration*	*Gantry girder – Design Concepts*	*Design applications of base plate*	*Numerical problems on purlins*	*Plate girder – Design Concepts*

Learning Resources	1. *Subramanian.N, "Design of Steel Structures-Limit State Method", Oxford University Press, New Delhi, 2016* 2. *Duggal .S.K, "Limit State Design of Steel Structures", Tata McGraw Hill Publishing Company, New Delhi, 2010.*	3. *Ramamrutham .S., "Design of Steel Structures", DhanpatRai Pub., 2013* 4. *Vazirani .V.N, "Design and Analysis of Steel Structures", Khanna Publishes, 2003* 5. *Ramachandra .S, VirendraGhelot, "Limit State Design of Steel of Structures", Scientific Publishers, New Delhi,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	*20%*	-	*15%*	-	*15%*	-	*15%*	-	*15%*	-
	Understand										
Level 2	Apply	*20%*	-	*20%*	-	*20%*	-	*20%*	-	*20%*	-
	Analyze										
Level 3	Evaluate	*10%*	-	*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. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*1. Dr. S. SenthilSelvan, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*2. Dr.K.S. Satyanarayanan, SRMIST*

Course Code	18CEO401T	Course Name	ADVANCED PRESTRESSED CONCRETE STRUCTURES	Course Category	O	Open Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards		IS 1343: 2012	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know and utilize the concepts of prestress concrete to analyse prestress concrete sections*
CLR-2 :	*Understand about the importance of short and long term deflections and transfer of prestressing by bond*
CLR-3 :	*Understand about composite section under flexure and shear*
CLR-4 :	*Know about the process of design of pipes, piles and pavements*
CLR-5 :	*Understand to analyzefolded plates and shell*
CLR-6 :	*Make them familiar on continuous beam and concordant cable*

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 :	*Analyze the prestress concrete sections using different concepts*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-2 :	*Determine short and long term deflections and bond stress in prestressed concrete members*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-3 :	*Determinethe flexural and shear strength of prestressed composite section*	*3*	*75*	*75*	*H*	*H*	-	*H*	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-4 :	*Design the cylinder and non-cylinder pipe, piles and pavements*	*3*	*90*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-5 :	*Design folded plates and shell*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-6 :	*Analyze primary, secondary and resultant moments on continuous beam and identify the concordant cable*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*PRESTRESSED CONCRETE* *Introduction - Basic concept – Principle of prestressing – Materials.*	*DEFLECTIONS* *Reasons to control deflections – Factors influencing deflections – short term deflection – uncracked section - Mohr's theorems*	*COMPOSITE CONSTRUCTION* *Introduction – composite action - advantages – types of composite construction.*	*DESIGN OF PIPES* *Design of non-cylinder pipes – losses of prestress.*	*FOLDED PLATES* *Introduction - types of folded plates –slab action – plate action – Names of methods for analysis.*
	SLO-2	*Forms of steel – systems of prestressing*		*Methods of construction – propped – unpropped construction.*		
S-2	SLO-1	*Types of prestressing – uses of prestressed concrete.*	*Deflection due to different cable profiles*	*Analysis of stresses*	*Example*	*Design example*
	SLO-2	*Materials – concrete strength limitation – requirements of steel for prestressed concrete.*	*Example*	*Example*		
S-3	SLO-1	*Analysis – basic assumptions.*	*Example*	*Examples*	*Example*	*Design example*
	SLO-2	*Concentric and eccentric tendons – resultant stresses – at transfer – at service. Concepts of prestressing – rectangle – symmetrical I-section only.*				
S-4	SLO-1	*Stress concept*	*Prediction of long term deflections - Example*	*Flexural strength of composite section.*	*Design of cylinder pipes* *Design of shear reinforcement*	*SHELL* *Introduction –advantages – methods of prestressing – design.*
	SLO-2			*Example*		
S-5	SLO-1	*Stress concept – examples*	*Examples*	*Example*	*Example*	*Design example*
	SLO-2					
S-6	SLO-1	*Stress concept - examples*	*Examples*	*Example*	*DESIGN OF PILES* *Advantages – driving stresses – service*	*Design example*
	SLO-2					

					load stresses - reinforcements.	
S-7	SLO-1	*Strength concept - examples*	*BOND*	*Shear strength of composite section.*	*Example*	*CONTINUOUS BEAMS*
	SLO-2		*Transmission of prestressing force - transmission length.*			*Advantages – effects of prestressing - primary moment – secondary moment – resultant moment – pressure line.*
S-8	SLO-1	*Load balancing concept – cable profile – reaction – equivalent loads.*	*Example*	*Example*	*DESIGN OF PAVEMENTS*	*Use of theorem of three moments - example*
	SLO-2				*General features – design of prestress in pavements.*	
S-9	SLO-1	*Load balancing concept – examples.*	*Bond stress – example.*	*Example*	*Example*	*Concordant cable profile – examples.*
	SLO-2					

Learning Resources	*1. Krishnaraju .R, "Prestressed Concrete", Tata McGraw-Hill Education, Edition: 2018, NewDelhi.* *2. Pandit .G.S, Gupta .S.P, "Prestressed Concrete", CBS Publishers & Distributors, 2008* *3. S. Ramamrutham, "Prestressed Concrete", DhanpatRai Publishing Company, Fifth Edition, Reprint 2016* *4. Lin T.Y, Design of, "Prestressed Concrete Structures", Asia Publishing House, Bombay 1995.*	*5. IS: 1343-2012 "IS Code of Practice for Prestressed Concrete", BIS, New Delhi, 2012.* *6. NPTEL Course: Prestressed Concrete Structures: https://nptel.ac.in/courses/105106117/*

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. Er. G.Hariharanath, GA Consultants, Chennai, gac1996@hotmail.com	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*1. Dr. K. Gunasekaran, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*2. Dr. P. R. Kannan Rajkumar, SRMIST*

Course Code	18CEO402T	Course Name	BRIDGE ENGINEERING	Course Category	O	Open Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18CEC207T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes/Standards		IS 456 : 2000, IRC 3-1983, IRC 112:2011, IRC 22: 2015, IRC:83-2018 (Part II)	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Comprehend the principles of bridge engineering*
CLR-2 :	*Acquire knowledge on the various types of IRC (Indian Road Congress) loads*
CLR-3 :	*Understand and evaluate the internal forces due to moving loads*
CLR-4 :	*Get familiarized with the design principles of different types of RCC bridges*
CLR-5 :	*Understand the principles of design of bridge substructure*
CLR-6 :	*Determine the forces in elastomeric bearings.*

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 :	*Choose the most appropriate type of bridge for the given conditions*	*3*	*75*	*60*	*H*	*H*	-	*H*	-	-	*L*	-	-	-	-	*L*	*H*	-	-
CLO-2 :	*Calculate the functional dimensions of a bridge across a waterway*	*3*	*75*	*60*	*H*	*H*	-	*H*	-	-	-	-	-	-	-	*L*	*H*	-	-
CLO-3 :	*Design slab type and girder type RCC bridges*	*3*	*90*	*85*	*H*	*H*	*L*	*H*	-	-	-	-	-	-	-	*L*	*H*	-	-
CLO-4 :	*Calculate the design forces on substructure*	*3*	*85*	*80*	*H*	*H*	*L*	*H*	-	-	-	-	-	-	-	*L*	*H*	-	-
CLO-5 :	*Design abutments and bridge foundations*	*3*	*75*	*70*	*H*	*H*	*L*	*H*	-	-	-	-	-	-	-	*L*	*H*	-	-
CLO-6 :	*Design Elastomeric bearings*	*3*	*75*	*60*	*H*	*H*	*L*	*H*	-	-	-	-	-	-	-	*L*	*H*	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*FUNDAMENTALS OF BRIDGE ENGINEERING & IRC LOADS Hydraulic factors influencing bridge design*	*DESIGN OF RCC SLAB BRIDGES Span limitations*	*DESIGN OF RCC T BEAM BRIDGES Span limitations*	*DESIGN OF BRIDGE SUBSTRUCTURE Abutment – types*	*DESIGN OF BEARINGS Definition of bearings*
	SLO-2	*Calculation of linear waterway*	*Analysis of simply supported slab due to concentrated loads – introduction*	*Configuration – spacing of T beams , end overhang*	*Forces affecting the stability of abutments*	*Forces on bearing*
S-2	SLO-1	*Effect of bridge on river regime*	*Effective width method for slab supported on opposite edges only*	*Introduction to Pigeauds method - deck slab supported on T beams*	*Problem solving to determine the stability of abutments*	*Types of bearings*
	SLO-2	*Economic span of bridge*	*Span-wise dispersion*	*Dispersed dimensions of wheel over the slab*	*Piers – types of piers*	*Basis for selection of bearings*
S-3	SLO-1	*Calculation of scour depth*	*Width-wise dispersion*	*Computation of bending moment using the curves for centrally placed wheel load*	*Loads on piers*	*Types of elastomeric bearings*
	SLO-2	*Design loads – IRC Class AA Class A*	*Analysis for bending*	*Design principles for longitudinal T beam girder – Courbon's theory*	*Analysis of piers*	*Behavior of elastomeric bearings under loads*
S-4	SLO-1	*Design loads – IRC Class A and B*	*Analysis for shear*	*Understanding the various terms in the formula and its application*	*Problem solving – preliminary dimensions*	*Dimensions of elastomeric bearings as per IRC: 82*
	SLO-2	*Impact effect*	*Design of slab bridge – computation of dead loads*	*Design of T beam bridge – preliminary dimensions – Class AA trackedload*	*Determination final stresses in the piers*	*Vertical stiffness – shape factor*
S-5	SLO-1	*Longitudinal forces*	*Positioning of IRC Class AA loads – tracked*	*Design of cantilever span*	*Bridge foundations – types*	*Thickness of bearing*
	SLO-2	*Centrifugal forces*	*Analysis for maximum bending moment & Shear force*	*Determination of maximum bending moment in the interior span of the deck slab – Pigeaud's method*	*Well foundations – types*	*Stresses on elastomeric bearings*
S-6	SLO-1	*Types of bridges – suitability of different types of bridges for various spans - slab bridges*	*Positioning of IRC Class AA loads – wheeled*	*Design of deck slab using limit state method*	*Components of well foundations*	*Slip in bearing*
	SLO-2	*Girder bridges*	*Analysis for maximum bending moment &*	*Analysis of longitudinal girder – dead loads*	*Design of well foundations – working*	*Shear deformation in bearing*

			Shear force	*bending and shear*	*stress method*	
S-7	SLO-1	*Continuous bridges – precautions from settlement considerations*	*Positioning of IRC Class A loads*	*Moving loads – bending*	*Pile foundations – pile groups*	*Stability of bearing*
	SLO-2	*Balanced double cantilever bridges*	*Analysis for maximum bending moment & Shear force*	*Moving loads – shear*	*Design principles of pile foundation*	*Uplift at the bearing*
S-8	SLO-1	*Arch bridges*	*Design using Limit state method - for bending moment*	*Computing the design bending and shear forces*	*Design forces*	*Influence of steel plates in the bearing*
	SLO-2	*Fundamentals of analysis using moving loads*	*Design for shear*	*Design of girder using limit state method – bending*	*Design using working stress method*	*Design of bearing – input loads*
S-9	SLO-1	*Determination of absolute maximum reaction*	*Detailing of reinforcement*	*Design for shear*	*Structural detailing*	*Design of bearing for stresses*
	SLO-2	*Determination of absolute maximum shear and bending moment due to moving loads*	*Sketching the cross section to show structural details*	*Detailing with sketches*	*Sketching the cross section to show structural details*	*Check for deformation*

Learning Resources	1. *Johnson Victor .D, "Essentials Of Bridge Engineering", Oxford University Press, Sixth edition, 2018* 2. *Jagadeesh.T.R, Jayaram .M.A, "Design Of Bridge Structures", Prentice – Hall of India Pvt. Ltd., 2009.* 3. *Krishna Raju .N, "Design of Bridges", Oxford & IBH Publishing Company Pvt. Ltd., Fifth edition, 2018* 4. *IRC:3-1983, Dimensions & Weights of Road Design Vehicles (First Revision), IRC, 1983.* 5. *IRC:5-2015, Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design (Eighth Revision), IRC, 2015.* 6. *IRC:6-2017, Standard Specifications and Code of Practice for Road Bridges, Section-II Loads and Load Combinations (Seventh Revision), IRC, 2017* 7. *IRC:22-2015, Standard Specifications and Code of Practice for Road Bridges, section VI – Composite Construction (Limit States Design) (Third Revision), IRC, 2015.* 8. *IRC:45-1972, Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges, IRC, 1972.* 9. *IRC:78-2014, Standard Specifications and Code of Practice for Road Bridges, Section VII-Foundations and Substructures (Revised Edition), IRC, 1974.* 10. *IRC:83-2018, (Part II), Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings (Elastomeric Bearings), Part II (Second Revision), IRC, 2018.* 11. *IRC:112-2011, Code of Practice for Concrete Road Bridges, IRC, 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 %*	-	*40 %*	-	*40 %*	-	*10 %*	-	*40%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*85 %*	-	*55%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*5 %*	-	*5%*	-
	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
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2. Er. (Mrs.) Mekala Ponmalar Gurubaran, National Highways, Tamilnadu, gmekalaponmalar@yahoo.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*2. Dr. K. S.Satyanarayanan, SRMIST*

Course Code	18CEO404J	Course Name	FUNDAMENTALS OF COMPUTING	Course Category	O	Open Elective Course	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learning of basics of computer programming using C, Java, Python*
CLR-2 :	*Description of basic syntax of C, Java, Python programming*
CLR-3 :	*Description of Data types, variables and key words*
CLR-4 :	*Illustrate the use of reserved words, operators*
CLR-5 :	*Understand the need of using statements, Loops in programming*
CLR-6 :	*Knowing about numbers, decisions*

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 of C, Java, Python languages*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-2 :	*Writing simple programs by using C, Java, Python programming languages*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-3 :	*Programming by using data types, variables and key words*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-4 :	*Express proficiency in using of reserved words and operators*	*2*	*85*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-5 :	*Identify the operations is using statements, loops in programming*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
CLO-6 :	*Expertise in making decisions and in using numbers for operation*	*3*	*85*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview*	*Data types*	*C programming reserved words*	*If..else statement*	*Loops in Python* *Loops in C*
	SLO-2	*Introduction to computer program*	*C and Java Data types*	*Java programming reserved words*	*If… else…if statement (if..elseif..else)*	*Numbers*
S-2	SLO-1	*Introduction to computer programming*	*Python Data types*	*Python programming reserved words*	*The switch statement*	*Math operation on Numbers*
	SLO-2	*Uses of computer programs (Advantages of Computer Programs)*	*Variables*	*Operators*	*Decisions in Java, Python (Decisions in C, Java, Python)*	*Numbers in Java, Python*
S-3	SLO-1	*Lab Session 1:* *Understanding of Computer Hardware and programming environment of C, Java and python Languages.*	*Lab Session 3:* *Initialization of data types in C, Java and Python .*	*Lab Session 5:* *Demonstrate the use of reserve words in C, Java, and Python*	*Lab Session 7:* *Develop a program using Decision statement.*	*Lab Session 9:* *Develop a program to solve computational problems using Math Operators.*
	SLO-2					
S-4	SLO-1					
	SLO-2					
S-5	SLO-1	*Algorithm*	*Creating variables*	*Arithmetic operators*	*Loops*	*Characters*
	SLO-2	*Basics of Programming*	*Store values in variables*	*Relational operators*	*The while loop*	*Escape sequences*
S-6	SLO-1	*Text editor, Compiler*	*Access stored values in variables*	*Logical operators*	*The do..while loop*	*Characters in Java* *Characters in C?*
	SLO-2	*Interpreter, Online Compilation*	*Variables in Java (Variables in C, Java Family and Python)*	*Operators in Java (Operators in C, Java)*	*The break statement*	*Characters in Java*
S-7	SLO-1	*Lab Session 2:* *Understanding the concept of Algorithm, Flowchart, Naming the program files, Storing, Compilation, Execution and Debugging.*	*Lab Session 4:* *Initialization of variables in C, Java and Python .*	*Lab Session 6:* *Understand and Develop a program to solve simple computational problems using arithmetic operators, relational and logical operators.*	*Lab Session 8:* *Develop a program using loop statement.*	*Lab Session 10:* *Understanding of Escape and Character sequences*
	SLO-2					
S-8	SLO-1					
	SLO-2					
S-9	SLO-1	*Basic Syntax of C and Java programming*	*Variabes in Python*	*Operators in Pyhon*	*The continue statement*	*Characters in Python*
	SLO-2	*Simple programs in C*	*Key words*	*Decision statements*	*Loops in Java*	*Characters in Python*

Learning Resources	1. *Programming in C by E. Balagurusamy, Mcgraw hill publications (India), New Delhi* 2. *Programming in Java by E. Balagurusamy , McGrawHill Publications(India), New Delhi* 3. *Programming in Python by E. Balagurusamy , McGrawHill Publications (India), New Delhi*	4. *Wesley J Chun, "Core Python Applications Programming", 3rd Edition, Pearson Education India, 2015. ISBN-13: 978-9332555365* 5. *https://nptel.ac.in/noc/individual_course.php?id=noc18-cs33* 6. *https://nptel.ac.in/courses/106105191/* 7. *https://nptel.ac.in/courses/117106113/34*

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, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er. S. Dhanabal, General Manager, NLY, Neyveli, dhans1960@yahoo.co.in	*1. Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR*	*Mr. Shaik Niyazuddin Guntakal, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. P. Jayabalan, NIT, Trichy, pjeya@nitt.edu*	*Mr. C. Arun, SRMIST*

Course Code	18CSO101T	Course Name	IT INFRASTRUCTURE MANAGEMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science& Engg.	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
CLR-1 :	*Understand the design factors and challenges in IT Infrastructure Management*	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-2 :	*Understand service delivery and associated processes*																		
CLR-3 :	*Understand storage and security management related to IT Infrastructure*																		
CLR-4 :	*Understand performance and tuning processes and associated case studies*																		
CLR-5 :	*Understand the suitable for combinations in information technology, business administration and electronic*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Be able to describe the business value and processes of ICT services in an organization and apply that knowledge and skill with initiative to a workplace scenario*	*2*	*80*	*85*	*L*	-	*L*	*H*	*L*	-	-	-	*H*	*H*	*M*	*L*	-	-	-
CLO-2 :	*Be able to investigate, critically analyze and evaluate the impact of new and current ICT services to an organization*	*2*	*75*	*80*	*M*	-	-	*H*	*H*	-	-	-	*L*	*L*	*L*	*H*	-	-	-
CLO-3 :	*Be able to describe how effective IT Infrastructure Management requires strategic planning with alignment from both the IT and business perspectives in an organization*	*2*	*85*	*80*	*M*	*L*	*M*	*H*	*L*	-	-	-	*M*	*H*	*H*	*H*	-	-	-
CLO-4 :	*Be able to demonstrate the technical and communications skills that contribute to the operation of ICT services in an organization*	*2*	*80*	*75*	*M*	*L*	*L*	*L*	-	-	-	-	*H*	*H*	*M*	*L*	-	-	-
CLO-5 :	*Be able to reflect critically on the role of an enterprise architect in an organization*	*2*	*75*	*85*	*L*	-	*L*	*L*	-	-	-	-	*L*	*L*	*H*	*L*	-	-	-
CLO-6 :	*Be able to synthesize the theoretical, technical and management issues that deliver ICT services to an organization*	*2*	*80*	*85*	*H*	-	*L*	*L*	*L*	-	-	-	*L*	*L*	*H*	*L*	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction – IT Infrastructure*	*Service Delivery And Support Process - Intro*	*Storage And Security Management - Intro*	*Performance And Tuning Process*	*Case Studies*
	SLO-2	*Challenges in IT Infrastructure Management*		*Backup and Storage, Archive & Retrieve*		
S-2	SLO-1	*Design Factors for IT Organizations*	*Service Level Management*	*Space Management*	*Introduction on tuning process*	*Asset Network Corporation case*
	SLO-2	*Design Factors for IT Infrastructures*				
S-3	SLO-1	*Determining customer's Requirements,*	*Financial Management*	*Hierarchical space management*	*Difference between Performance and Tuning processes and other Infrastructure processes*	*Radio Shack case*
	SLO-2	*Identifying System Components to manage*				
S-4	SLO-1	*Identifying System Components to manage*	*IT Service Continuity Management*	*Database & Application protection*	*Definitions*	*Business Process Outsourcing (BPO) Infrastructure Planning and Management*
	SLO-2					
S-5	SLO-1	*Exist Processes, Data, applications,*	*Capacity Management*	*Disaster Recovery Bare Machine Recovery (BMR)*	*Preferred characteristics*	*e-Commerce Business Infrastructure Planning and Management*
	SLO-2					
S-6	SLO-1	*Tools and their integration*	*Configuration Management*	*Data Retention*	*Performance and tuning applied to major resource environments*	*Enron case*
	SLO-2					
S-7	SLO-1	*IT Systems and Service Management Process*	*Service desk, Incident management*	*Computer Security Identity Management*	*Assessing an Infrastructure's performance and tuning process*	*Tycocase*
	SLO-2					

S-8	SLO-1	Information systems Design Process	Availability management,	Access control system	Measuring and streamlining the P and T process	Worldcom case
	SLO-2					
S-9	SLO-1	IT Infrastructure Library	Release Management	Intrusion Detection	Performance tuning recommendations for data and event management	Analyze an information infrastructure – case study
	SLO-2					

Learning Resources	1. *Rich Schiesser, " IT Systems Management", 2nd edition, 2010, Pearson Education, ISBN: 978-0137025060* 2. *P.Gupta,"ITInfrastructureandItsManagement"2ndReprint,2010,TataMcGrawHill,ISBN: 978-0070699793* 3. *SjaakLaan,"ITInfrastructureArchitecture:InfrastructureBuildingBlocksandConcepts",2011, Lulu Press Inc, ISBN978-1-4478-8128-5.*	4. *LeonardJessup,JosephValacich,"InformationSystemToday:ManagingDigitalWorld",3rdEdition, 2007, Prentice Hall, ISBN:0-13-233506-9.* 5. *Hausman,Cook,"ITArchitectureforDummies",2011,WileyPublishing,Hoboken,NJ www.wiley.com ISBN:978-0-470-55423-4* 6. *RichardJ.Reese,"ITArchitectureinAction",2008,XlibrisPublishing,ISBN:978-1-4363-0505-1*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								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. Mohamed Yaseen MS, Technical Business Analyst, CBA - Sydney, Australia, yasucseau@gmail.com	*1. Dr.J.Baskar Babujee, Associate Professor, Madras Institute of Technology,Chennai. baskarjee@annauniv.edu*	*1. Dr. C.N.S.Vinoth Kumar, SRMIST*
2. Mr.P.AnandaNatarajan,Senior Associate Consultant, Infosys, Chennai., anand_adnan@yahoo.com		*2. Dr. MB.Mukesh Krishnan, SRMIST*

Course Code	18CSO102T	Course Name	MOBILE APPLICATION DEVELOPMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science &Engg	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)															
CLR-1 :	*Understand the basics of Android devices andPlatform.*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Acquire knowledge on basic building blocks ofAndroid programming required for Appdevelopment.*	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-3 :	*Understand persistence Data storage mechanismin Android*																		
CLR-4 :	*Understand advanced application concepts likenetworking, Animations and Google Maps services etc.*																		
CLR-5 :	*Develop and publish Android applications in toAndroid Market*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Acquire the knowledge on Android devices and Platform*	2	80	85	L	-	-	-	H	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire knowledge on basic building blocks ofAndroid programming required for Appdevelopment.*	2	75	80	L	-	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply the knowledge of persistence Data storage mechanismin Android*	2	85	80	-	-	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the knowledge in advanced application concepts likenetworking, Animations and Google Maps services etc.*	2	80	75	L	-	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Design and apply the knowledge to publish Android applications in toAndroid Market*	2	75	85	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	7	10	10
S-1	SLO-1	*Introduction: Introduction to mobile application development, trends.*	*GUI for Android: Introduction to activities life-cycle*	*Introduction to Different Data persistence schemes*	*Services :introduction to services–localservice,*	*Introduction to Location based services*
	SLO-2					
S-2	SLO-1	*introduction to various platforms,*	*Android v7 supportlibrary form API21 for lower versionsupport*	*Shared preferences*	*remote service and binding theservice,.*	*Google maps V2 services using Google API.*
	SLO-2					
S-3	SLO-1	*introduction to smart phones*	*Intent :intent object*	*File Handling se*	*the communication between serviceand activity, Intent Service*	*Animations and Graphics: Property Animation .*
	SLO-2					
S-4	SLO-1	*Android platform: Android platform,features and architecture,*	*intent filters ,addingcategories*	*Managing data using SQLite databa*	*MultiThreading: Handlers*	*View Animations, DrawableAnimations*
	SLO-2					
S-5	SLO-1	*versions ,comparison added features in each versions.*	*linking activities, user interfacedesign components*	*Content providers:*	*,AsyncTask*	*Media and Camera API: Working withvideo and audio inputs*
	SLO-2					
S-6	SLO-1	*ART(Android Runtime),ADB(AndroidDebug Bridge).*	*Views and View Groups: Basic views,picker views, adapter views, Menu, App Baretc, basics of screen design; differentlayouts.*	*user content provider*	*android network programming:HttpUrlConnection*	*Camera API*
	SLO-2					
S-7	SLO-1	*Development environment/IDE: Android studio and its working environment*	*App widgets.Lollipop Materialdesign: new themes, new widgets,Cardlayouts. RecyclerView*	*Android in build content providers*	*Connecting to REST-based and SOAP based Web services*	*Sensor programming: Motion sensors*
	SLO-2					
S-8	SLO-1	*gradle build system, emulator setup*	*Fragments: Introduction to activities,*		*Broad castreceivers:LocalBroadcastManager,Dynamic broadcast receiver*	*Position sensors, Environmental sensors.*
	SLO-2					
S-9	SLO-1	*Application anatomy:*	*activities life-cycle.*		*System Broadcast. PendingIntent, Notifications*	*Publishing Android Apps: Guide lines.*
	SLO-2	*Applicationframework basics: resources layout, values,asset XML representation*				

		and generatedR.Javafile ,Android manifest file. Creating asimple application.				
S-10					*Telephony Manager:Sending SMS andmaking calls.*	*policies and process of uploading Apps toGoogle play*

Learning Resources	1. *Dawn Griffiths, David Griffiths,"Head First: Android Development" ,OReilly2015,ISBN:9781449362188.* 2. *Greg Milette,Adam Stroud,"PROFESSIONALAndroid™ Sensor Programming", John Wiley and Sons, Inc2012,ISBN/978111265055,9781280678943,978111227459*	3. *PaulDeital, Harvey Deital, AlexanderWald, "Android6 for Programmers, App Drivenapproach",2015, Prentice Hall ,ISBN:9780134289366.* 4. *http://developer.android.com/training/index.htmlas on Date21.4.2016*

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. Dr. KHANNA NEHEMIAH , Professor, Ramanujan Computing, Anna University	*1. Dr.M.UMA*
		2. Dr.Ganesh Kumar, SRMIST
		3.Mr.K.Naveen

Course Code	18CSO103T	Course Name	SYSTEM MODELING AND SIMULATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Select a suitable modeling method according to problem area and assignment, and justify their choice.*
CLR-2 :	*Formulate models of a system to describe the system on different levels of abstraction and from different viewpoints.*
CLR-3 :	*Learn and apply the continuous system simulation*
CLR-4 :	*Learn theory and probability concepts in simulation*
CLR-5 :	*Learn the simulation languages and 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 :	*Implement the appropriate modeling method for the given problem*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Explain the system abstraction in different levels*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply the models under continuous system simulation*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Analyze the probability concepts for simulating a system*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Apply tools to like GPSS and SIMSCRIPT to check model properties of a system*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to system modelling*	*Continuous System Simulation - Introduction*	*Probability Theory*	*Queueing Theory - Introduction*	*General description of GPSS and SIMSCRIPT*
S-2	SLO-1	*Modeling principles and concepts*	*Numerical solution of differential equations*	*Probability CONCEPTS IN SIMULATION -*	*Arrival Pattern distributions*	*programming in GPSS*
S-3	SLO-1	*Continuous systems and Discrete systems*	*Analog computers*	*Monte Carlo techniques*	*servicing times, queuing disciplines*	*Application of GPSS on specific problem*
S-4	SLO-1	*Modeling, types of models,subsystems*	*Hybrid computers*	*Application of Monte Carlo techniques*	*measure of queues*	*Simulation Programming Techniques*
S-5	SLO-1	*corporate model, system study..*	*continuous system simulation languages CSMP*	*Stochastic variables*	*mathematical solutions to queuing problems*	*Data Structures*
S-6	SLO-1	*System Simulation: Techniques,*	*system dynamic growth models,*	*probability functions*	*Discrete system simulation: Events*	*Implementation of activities*
S-7	SLO-1	*comparison of simulation and analytical methods*	*logistic curves*	*Random Number Generation algorithms*	*Generation of arrival pattern*	*Events and queues, event scanning*
S-8	SLO-1	*types of simulation, distributed log models*	*Illustration of Continuous System Simulation*	*Illustration of Probability concepts*	*Simulation programming tasks*	*Simulation algorithms in GPSS and SIMSCRIPT*
S-9	SLO-1	*cobweb models*	*Case Study*	*Case Study*	*Analysis of simulation output*	*Case Study*

Learning Resources	
	1. *Geoffery Gordon, " System Simulation" , PHI, 2nd edition*
	2. *Jerry Banks , John S.Carson ,Barry Nelson, David M.Nicol, "Discrete – Event System Simulation", PHI, 3rd edition*
	3. *Karian. Z.A., Dvdewicz .E.Z, "Modern Statistical Systems and GPSS Simulation",Freeman, 1991*

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. Prof.S.S.Sridhar, SRMIST
		2. Mr. C.Arun, SRMIST

Course Code	18CSO104T	Course Name	FREE AND OPEN SOURCE SOFTWARES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	*Be exposed to the context and operation of free and open source software (FOSS) communities and associated software projects.*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Be familiar with participating in a FOSS project*	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-3 :	*Learn scripting language like Python or Perl, Ruby*																		
CLR-4 :	*Learn some important FOSS tools and techniques*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Install and run open-source operating systems.*	*3*	*80*	*70*	*L*	*H*	*-*	*H*	*L*	*-*	*-*	*-*	*L*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-2 :	*Gather information about Free and Open Source Software projects from software releases and from sites on the internet.*	*3*	*85*	*75*	*M*	*H*	*L*	*M*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-3 :	*Build and modify one or more Free and Open Source Software packages.*	*3*	*75*	*70*	*M*	*H*	*M*	*H*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-4 :	*Contribute software to and interact with Free and Open Source Software development projects.*	*3*	*85*	*80*	*M*	*H*	*M*	*H*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*H*	*-*	*-*	*-*
CLO-5 :	*Identify and apply various linux commands*	*3*	*85*	*75*	*H*	*H*	*M*	*H*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*H*	*-*	*-*	*-*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-*	*Linux Installation and Hardware Configuration*	*Unix file system, Unix files, i-nodes and structure and file system relatedcomm ands*	*Usage of design Tools like Argo UML or equivalent*	*Open Source Software Development*
	SLO-2	*Open Source, Free Software, Free Software vs. Open Source software*				
S-2	SLO-1	*FOSS examples*	*Boot Process-The Linux Loader (LILO)*	*Shell Programming, Shell as command processor, Shell vari ables*	*Version Control Systems like Git or equivalent*	*Case Study – Libreoffice -Samba*
	SLO-2	*FOSS Characteristics*	*The Grand Unified Boot loader (GRUB)*			
S-3	SLO-1	*FOSS History, Examples*	*Dual-Booting Linux and other Operating System*	*Creating command substitution, Scripts*	*Bug Tracking Systems*	
	SLO-2	*FOSS Copyright*	*Boot-Time Kernel Options*			
S-4	SLO-1	*Guidelines for effectively working with*	*Basic Linux Commands*	*Creating commands for Functions, Conditionals*	*Package Management Systems*	
	SLO-2	*FOSS community*				
S-5	SLO-1	*Benefits of Community based Software*	*Linux Commands for operations - redirection, pipes, filters, job control, changing ownership/permission of files/directories*	*Creating commands for loops*	*Introduction to Programming language using Python*	
	SLO-2	*Development*				
S-6	SLO-1	*Requirements for being open, free*	*Advanced Linux Commands like curl, wget, ftp, ssh and grep*	*Customizing environment*	*Basic commands, variables, Decision Making, Lists, Modules, strings, looping,*	*Case Studies : Apache, BSD, Linux, Mozilla (Firefox), Wikipedia, Joomla, GCC,*
	SLO-2	*software, open source software*				

S-7	SLO-1	*Four degrees of freedom*	*X Windows System Configuration*	*Shell scripting for system configurations*	*conditional statements, classes, Exceptions packages*	*Open Office*
	SLO-1					
S-8	SLO-1	*FOSS Licensing Models*	*System Administration*	*Shell scripting with functions and conditions*		
	SLO-2	*FOSS Licenses – GPL- AGPL- LGPL – FDL*	*Backup and Restore Procedures*			
S-9	SLO-1	*Implications*	*Strategies for keeping a Secure Server*	*Shell scripting with looping*		
	SLO-2					

Learning Resources	1. *EllenSiever,StephenFiggins,RobertLove,ArnoldRobbins,"LinuxinaNutshell",Sixth Edition, OReilly Media, 2009.* 2. *LinuxProgrammingBiblebyJohnGoerzen,IDGBooks,NewDelhi,2000.* 3. *Your Unix - The Ultimate Guide by Sumitabha Das, TMH,2000*	4. *PerlProgrammingbookathttp://www.perl.org/books/beginning-perl/.* 5. *Rubyprogrammingbookathttp://ruby-doc.com/docs/ProgrammingRuby/.* 6. *Samba: URL :http://www.samba.org/.*

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 %		-	

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.BijoymonSoman *Sr. Test Analyst* *UST Global,* *Philadelphia,PA, USA*	*1. Dr.Arun kumar M N* *Assistant Professor,* *Federal Institute of Science and Technology,* *Angamaly, Kerala*	*1. Mrs Aswathy K Cherian, SRMIST*
		2.Mrs. Nimala , SRMIST

Course Code	18CSO105T	Course Name	ANDROID DEVELOPMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of Android devices and Platform.*
CLR-2 :	*Acquire knowledge on basic building blocks of Android programming required for Application development*
CLR-3 :	*Gain knowledge to user interfaces used in android applications*
CLR-4 :	*Acquire knowledge on advanced application concepts like networking, Animations and Google Maps services etc*
CLR-5 :	*Develop and publish Android applications in to Android Market*
CLR-6 :	*Understand the knowledge of JSON and MQTT*

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 :	*To exposed to technology and business trends impacting Android Platform*	*2*	*80*	*85*	*H*	-	*L*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Be competent with the characterization and architecture of mobile applications*	*2*	*75*	*80*	*L*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*To understanding enterprise scale requirements of mobile applications*	*2*	*85*	*80*	*H*	-	*H*	*L*	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*To designing and developing mobile applications using one application development framework*	*2*	*80*	*75*	*L*	*L*	*H*	-	-	-	-	-	-	-	*M*	-	-	-	-
CLO-5 :	*To understand how to handle and share android data*	*2*	*75*	*85*	*L*	-	*H*	*H*	*L*	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*To develop an android services and to publish android application for use*	*2*	*80*	*85*	*H*	-	*H*	-	-	-	-	-	-	-	*M*	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Creating a new Android Project*	*Hosting a UI Fragment*	*Action Bar and Options Menus*	*Loopers, Handlers, and HandlerThread*	*Introduction to JSON*
	SLO-2	*Defining the Project and SDK setting*	*Creating a UI Fragment*	*Enabling Ancestral Navigation*	*Creating a search interface*	*JSON and Android*
S-2	SLO-1	*Creating an Android Virtual Device (AVD) in Android Studio*	*Adding a UI Fragment to the FragmentManager*	*An Alternative Menu Item*	*Hardware search button*	*Designing JSON and JSON Operation*
	SLO-2	*Android Virtual Device (AVD) in Android Studio*	*The FragmentManager and the fragment lifecycle*	*Saving and Loading Local Files*	*Creating an IntentService*	*Server reachability and Connection & Splash App*
S-3	SLO-1	*Configuring the Android Studio AVD Emulator*	*Creating User Interfaces with Layouts and Widgets*	*Context Menu Resource*	*Delayed Execution with AlarmManager*	*Lazy Loading Images*
	SLO-2	*The Emulator Environment and Toolbar Options*	*XML Layout Attributes*	*Floating Context Menu*	*Broadcast Intents*	*Lazy loading Libraries*
S-4	SLO-1	*Extended Control options*	*the Graphical Layout Tool*	*Contextual Action Mode*	*Waking Up on Boot*	*Lazy loading Archirtecture*
	SLO-2	*Drag and Drop Support*	*Creating a ListFragment*	*Camera I: Viewfinder*	*Filtering Foreground Notifications*	*Handling Image Assets*
S-5	SLO-1	*Configuring Fingerprint Emulation*	*Hosting a Fragment*	*Using the Camera API*	*Receivers and Long-running Tasks*	*Remote Crash Logs and App*
	SLO-2	*Android Studio Apps on a Physical Android Device*	*ListFragment, ListView and ArrayAdapter*	*Camera II: Taking Pictures and Handling Images*	*Browsing The Web & WebView*	*Push Messaging Services*
S-6	SLO-1	*Enabling ADB on Android based Devices*	*Fragment Arguments*	*Updating the Model Layer*	*Custom Views and Touch Events*	*Firebase Cloud Messaging*
	SLO-2	*Android Studio Editor*	*ViewPager*	*Updating CrimeFragment's View*	*Creating BoxDrawingView*	*Open Source Push Messaging with MQTT*

S-7	SLO-1	*Splitting the Editor Window, Code Completion, Statement*	*Dialogs*	*Implicit Intents*	*Handling Touch Events*	*MQTT App and Project*
	SLO-2	*Parameter Information, Parameter Name Hints,*	*Audio Playback Using MediaPlayer*	*Two-Pane Master-Detail Interfaces*	*Tracking the Device's Location*	*Message Brokers*
S-8	SLO-1	*Code Generation*	*Retained Fragments*	*Adding Layout Flexibility*	*Locations and the LocationManager*	*MQTT Broker setup for AWS*
	SLO-2	*Code Folding*	*Rotation and Retained Fragments*	*Activity: Fragment Boss*	*Receiving Broadcast Location Updates*	*Sending Messages with MQTT Web Clients*
S-9	SLO-1	*Quick Documentation Lookup*	*Rotation Handling and onSaveInstanceState(Bundle)*	*Styles And Includes*	*Updating the UI with Location Data*	*Firebase Cloud Messaging*
	SLO-2	*Code Reformatting*	*Localization*	*Cleaning Up with Styles*	*Testing Locations on Real and Virtual Devices*	*MQTT Push Messaging*

Learning Resources	1. *Neil Smyth, Kotlin / Android Studio 3.0 Development Essentials - Android 8 Edition, Payload Media, Inc.2017* 2. *BillPhillipsandBrianHardy,AndroidProgramming:TheBigNerdRanchGuide,BigNerdRanch,Inc. 2013*	3. *MarkWickham,PracticalAndroid:14CompleteProjectsonAdvancedTechniquesandApproaches, Apress,2018* 4. *DavidGriffiths,HeadFirst:AndroidDevelopment,OReilly2015,ISBN:9781449362188*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								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. *DineshBabuT,DevelopmentManager,HPIndia.dinesh.thavamani@hp.com*		1. *Mr.S.Pradeep,SRMIST*
2. *SurajSundaram,AssociateITConsultant,TCSCanada.suraj.s@tcs.com*		2. *Mr. C. Arun,SRMIST*

Course Code	18CSO106T	Course Name	DATA ANALYSIS USING OPEN SOURCE TOOL	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Computer Science and 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 and write programs in R*																		
CLR-2 :	*Gain knowledge on the working of statistical data in R*																		
CLR-3 :	*Gain knowledge on Linear regression and manipulation in R*																		
CLR-4 :	*Acquire knowledge on classification and clustering in R*																		
CLR-5 :	*Acquire knowledge on Linear Model selection and regulaization and working it in R*																		
CLR-6 :	*Introduce the Tree baed methods and working it in R*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Acquire the knowledge on data analysis in R*	2	80	85	H	-	-	-	H	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the ability to find meaning pattern using R*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Acquire the ability to find graphically interpret data in R*	2	75	80	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the knowledge for implementing anlaytical alogirthms*	2	80	75	H		-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Handle large scale analytics projects from various domains*	2	75	85	H	H	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Develop intelligent decision support systems*	2	75	80	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Data in data analytics*	*Simple Linear Regression*	*An Overview of Classification*	*Cross-Validation The Validation Set Approach*	*The Basics of Decision Trees- Regression Trees*
	SLO-2	*NOIR classification*	*Estimating the coefficients*	*Logistic Regression - The Logistic Model*	*Leave-One-Out Cross-Validation*	*Classification Trees*
S-2	SLO-1	*Introduction to R*	*Assessing the Accuracy of the Coefficient Estimates*	*Estimating the Regression Coefficients*	*k-Fold Cross-Validation*	*Trees Versus Linear Models*
	SLO-2	*Data types*	*Assessing the Accuracy of the Model*	*Making Predictions*	*Bias-Variance Trade-Off for k-Fold Cross-Validation*	*Advantages and Disadvantages of Trees*
S-3	SLO-1	*Control structures*	*Libraries for Simple Linear Regression in R*	*Multiple Logistic Regression*	*The Validation Set Approach in R*	*Bagging -Random Forests*
	SLO-2	*Control structures - Using the console*	*Programming in simple linear regression in R*	*Logistic Regression for >2 Response Classes*	*Leave-One-Out Cross-Validation in R*	*Boosting*
S-4	SLO-1	*Objects in R - Numbers, Attributes*	*Multiple Linear Regression - Estimating the Regression Coefficients*	*Linear Discriminant Analysis - Using Bayes' Theorem for Classification*	*k-Fold Cross-Validation .in R*	*Fitting Classification Trees in R*
	SLO-2	*Vectors - create vectors*	*Multiple Linear Regression in R*	*Linear Discriminant Analysis for p = 1*	*The Bootstrap in R*	*Fitting Regression Trees in R*
S-5	SLO-1	*Using [] brackets*	*Extensions of the Linear Model*	*Linear Discriminant Analysis for p>1*	*Linear Model Selection and Regularization- Subset Selection*	*Bagging and Random Forests in R*
	SLO-2	*Vectorized operations*	*Potential Problems*	*Quadratic Discriminant Analysis*	*Stepwise Selection Choosing the Optimal Model*	*Boosting in R*
S-6	SLO-1	*Matrix -building a matrix, Naming dimensions, Colnames and Rownames*	*The Marketing Plan*	*Logistic Regression, LDA,*	*Shrinkage Methods Ridge Regression*	*Principal Components Analysis - What Are Principal Components?*
	SLO-2	*Matrix operations, Visualizing with Matplot()*	*Comparison of Linear Regression with K-Nearest Neighbors*	*QDA, and KNN in R - T*	*The Lasso Selecting the Tuning Parameter*	*More on PCA*

S-7	SLO-1	*Data frame*	*Qualitative Predictors*	*Example using Stock Market Data*	*Dimension Reduction Methods Principal Components RegressionP*	*Principal Components Analysis in R*
	SLO-2	*List*	*Extensions of the Linear Model*	*Logistic Regression in R*	*artial Least Squares*	*More on PCA - Other Uses for Principal Components*
S-8	SLO-1	*Functions*	*Interaction Terms in R*	*Linear Discriminant Analysis in R*	*Best Subset Selection in R*	*Clustering Methods- K-Means*
	SLO-2	*Indexing data*	*Non-linear Transformations of the Predictors in R*	*Quadratic Discriminant Analysis in R*	*Forward and Backward Stepwise Selection in R*	*Hierarchical Clustering*
S-9	SLO-1	*Reading data*	*Qualitative Predictors in R*	*K-Nearest Neighbors in R*	*Choosing Among Models Using the Validation Set Approach and Cross-Validation in R*	*K-Means Clustering in R*
	SLO-2	*Writing data*	*Writing Functions for linear regression in R*	*An Application to Caravan Insurance Data in R*	*Ridge Regression and the Lasso in R*	*Hierarchical Clustering in R*

Learning Resources	1. *G James, D. Witten, T Hastie, and R. Tibshirani, An Introduction to Statistical Learning: with Applications in R, Springer, 2013* 2. *Chambers, John, Software for Data Analysis Programming with R, Springer, 2008* 3. *Trevor Hastie Robert Tibshirani Jerome Friedman,The Elements of Statistical Learning, Data Mining, Inference, and Prediction (2nd Edn.), Springer, 2014*	4. *Mark Gardener,Beginning R: The Statistical Programming Language, Wiley, 2013* 5. *Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50%								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. Venkatesh K. Pappakrishnan, Ph.D. *Data scientist | Physicist, Santa Clara, California*	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr.V.Kavitha, SRMIST*
2. Prakash V, *Technical Lead at Bridgeline Digital Inc* *Greater Boston Area*	*2.Dr. Latha Karthigaa, PhD ,* *Innovation Research Assistant,* *The University of Auckland*	*2. Dr.Alice Nithya, SRMIST*

Course Code	18CSO107T	Course Name	IOS DEVELOPMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Couse 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
CLR-1 :	*Understand the basics of ios device and platform*	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-2 :	*Understand the basic building blocks of ios programming required for App development*																		
CLR-3 :	*Understand Data storage mechanism in ios*																		
CLR-4 :	*Understand advanced application concepts like animations, webservices,etc*																		
CLR-5 :	*Develop and publish ios application in to ios market*																		
CLR-6 :	*understanding enterprise scale requirements of mobile application*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Acquire the knowledge of ios device and platform*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Acquire the knowledge on ios programming for App Development*	*2*	*75*	*80*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Apply the concepts used for data storage in ios*	*2*	*85*	*80*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*Apply the animation and webservice concepts in the App*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Understand the basic idea to publish ios application into ios market*	*2*	*75*	*85*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand the needs of enterprise to develop App*	*2*	*80*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Top Mobile OS in Market*	*The Swift Language-Types*	*Programmatic views-anchors,Margins*	*Stack Views*	*Webservices*
	SLO-2	*Difference between IOS and Android*	*Literals and subscripting, Initializers, Properties, Instance methods*	*Programmatic controls*	*Nested stack views*	
S-2	SLO-1	*IOS Architecture*	*Optionals,Subscripting dictionaries, Loops and String Interpolation*	*Localization*	*Segues*	*JSON Data*
	SLO-2		*Enumerations*			
S-3	SLO-1	*History of IOS*	*Views-Basics*	*Internalization*	*UINavigation Controller*	*Collection views*
	SLO-2		*Frames, Customizing the labels*		*Dismissing the keyboard*	
S-4	SLO-1	*Requirements*	*The auto Layout System*	*Controlling Animations*	*Even handling basics*	*Extensions*
	SLO-2		*Adding Constraints*	*Completion,constraints*		
S-5	SLO-1	*Versions*	*Text Input- Editing,Keyboard attributes*	*Timing functions*	*Camera*	*Image caching*
	SLO-2					
S-6	SLO-1	*Framework -MVC Design Pattern*	*Dismissing the keyboard*	*Debugging*	*Saving,Loading and Application States*	*Core Data*
	SLO-2		*Number formatters*			
S-7	SLO-1	*Application Life Cycle*	*Delegation*	*UITableView and Controller*	*Loading files, Error handling*	*Fetch requests and predicates*
	SLO-2		*Conforming to a protocol*			
S-8	SLO-1	*Features*	*View controllers*	*Editing UITableview*	*Size class*	*Core Data Relationships*
	SLO-2		*UITabBarController*			
S-9	SLO-1	*A simple IOS Application*	*Appearing and accessing views*	*Subclassing UITableViewcell*	*Touch Events and UIResponder*	*Accessibility*
	SLO-2					

Learning Resources	
1.	*ChristianKeur,AaronHillegass,iosprogramming:TheBigNerdRanchGuide,6th ed.,Pearson,2016.*
2.	*Jon Hoffman, Mastering Swift,4th ed.,Packt Publishing Ltd.,2017.*
3.	*Fahim Farook, Matthijs Hollemans, ios Apprentice,7th ed.,Razeware LLC,2018.*
4.	*Michael Grant, ios Navigation101,2019.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50%								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.Mahendran, Founder, Dreams Technologies, Chennai.	*1.*	*1. Dr.D.Rajeswari, SRMIST*
2.	*2.*	*2. Mr.K.Navin, SRMIST*

Course Code	18EEO301T	Course Name	SUSTAINABLE ENERGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Enrich the students on the basics of solar energy*
CLR-2 :	*Develop the knowledge in wind energy conversion system*
CLR-3 :	*Understand the energy generation by biomass*
CLR-4 :	*Gain knowledge on ocean ,tidal energy*
CLR-5 :	*Acquire knowledge in fuel cell and its types*
CLR-6 :	*Apply the concepts of renewable energy in industrial applications*

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 :	*Obtain in depth knowledge on solar applications*	*2*	*80*	*75*
CLO-2 :	*Explain the concepts of wind energy conversion systems and their control*	*3*	*80*	*75*
CLO-3 :	*Summarize the biomass technologies and calculate the power conversion of biomass digestion*	*3*	*80*	*75*
CLO-4 :	*Interpret the environmental impacts of ocean and tidal energy*	*3*	*80*	*75*
CLO-5 :	*Summarize the working principle of fuels cells and its types*	*3*	*80*	*75*
CLO-6 :	*Infer the knowledge about various types of renewable energy systems*	*3*	*80*	*75*

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*	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
H	*M*	*M*	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
H	*M*	-	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
H	*M*	-	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
H	*M*	-	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-
H	*M*	*M*	-	-	-	*L*	-	-	-	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Solar radiation*	*Wind energy conversion*	*Biogas*	*Ocean thermal energy conversion*	*Fuel Cell*
	SLO-2	*Beam and diffuse radiation, solar constant, earth*	*Principles of Wind energy conversion*	*Energy from Biomass*	*Principle of OTEC*	*Basics of Fuel cell*
S-2	SLO-1	*Sun angles*	*Nature of the wind*	*Types of biomass*	*Lambert law of absorption*	*Components of fuel cells*
	SLO-2	*Calculation of angle of incidence*	*Factors influencing wind*	*Photosynthesis*	*OTEC power plant*	*Difference between batteries and fuel cell*
S-3	SLO-1	*Attenuation and measurement of solar radiation*	*Wind data and energy estimation- wind speed monitoring,*	*Factors affecting digestion system*	*Open loop system for ocean energy conversion*	*Types of fuel cells*
	SLO-2	*Local solar time, derived solar angles, sunrise, sunset and day length*	*Site selection*	*Classification of biogas plants*	*Closed loop system for ocean energy conversion*	*Ionic conductivity of fuel cell*
S-4	SLO-1	*Flat plate collectors, concentrating collectors*	*Power in the wind*	*Advantages and disadvantages of biogas plants*	*Single basin*	*Electronic conductivity in fuel cell*
	SLO-2	*Solar air heaters, types, solar driers*	*Betz limit*	*Factors affecting bio digestion*	*dual basin ocean energy conversion system*	*Principle of working of fuel cell*
S-5	SLO-1	*Storage of solar energy, thermal storage*	*Components of a wind energy conversion system*	*Biomass as Renewable Energy Source*	*Major problems and operational experience Tidal energy*	*Performance characteristics of fuel cells*
	SLO-2	*Solar pond , solar water heaters*	*Torque on wind*	*Cofiring*	*Site selection of tidal power plant*	*Selection of fuel cells*
S-6	SLO-1	*Solar distillation*	*Wind thrust calculations Repowering concept*	*Dry Process*	*Tide ,Spring tide*	*Fuel cell stack*
	SLO-2	*Solar Pond*	*Horizontal Axis Wind Turbine(HAWT design consideration)*	*Photosynthesis*	*Neap tide, Tidal range*	*fuel cell power plant*
S-7	SLO-1	*Solar heating & cooling of buildings*	*Tip Speed Ratio*	*Energy forming*	*Types of Tidal power plant*	*Cross section of typical PEM fuel cell*
	SLO-2	*Solar still, solar cooker*	*Solidity*	*Pyrolysis*	*Advantages and disadvantages of tidal power plant*	*Storage methods for fuel cells*
S-8	SLO-1	*Photo voltaic. Types of PV cells*	*Types of generators and power converters in WECS*	*Types of Biomass Fuels*	*Wave Energy*	*Challenges and trends in fuel cell*

	SLO-2	*Characteristics and working principles of PV*	*Control schemes for power converters.*	*Biomass power plant*	*Wave Characteristics*	*Efficiency of fuel cell*
S-9	SLO-1	*Maximum power point tracking methods*	*Introduction to grid integration of WECS*	*Biomass cogeneration*	*Different wave energy convertors, Saltor Duck*	*Applications of fuel cell*
	SLO-2	*Net metering concepts*	*Issues in grid integration*	*Digester design*	*Oscillating water column and dolphin types*	*Advantages and disadvantages of fuel cell*

Learning Resources	*1. Rai ,G.D.,Non Conventional sources of Energy, Khanna Publishers ,5th Edition 2016.* *2. Khan. B.H, "Non-Conventional Energy Resources", The McGraw Hills,2nd Edition, 2016*	*3. O'Hayre, R.P.,S. Cha, W. Colella, F.B.Prinz, Fuel Cell Fundamentals, Wiley, NY (2006).* *4. https://onlinecourses-archive.nptel.ac.in/.*

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. Er.P.Velumani, TANGEDCO ,velumaniyazhini@gmail.com	*1. Dr.P.DhamodHaran, IIITM, damodharan@iiitdm.ac.in*	*1. Dr.K.Saravanan, SRM IST*
2.Er.R.Ramanavasu,BAVINI,BARC,rramanavasu@igcar.gov.in	*2. Dr.S.Kumaravel , NIT Calicut,kumaravel_s@nitc.ac.in*	*2. Dr.R.Sridhar, SRM IST*

Course Code	18EEO302T	Course Name	ANALOG ELECTRONICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Know the basic amplifier circuits*
CLR-2 :	*Acquire knowledge on different power amplifiers*
CLR-3 :	*Construct different waveform generating circuits*
CLR-4 :	*Discuss the basics of operational amplifiers*
CLR-5 :	*Understand different analog to digital and digital to analog converters*
CLR-6 :	*Design amplifier circuits using transistor and operational amplifiers*

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 :	*Analyze the amplifier circuits using small signal model and hybrid model*	*2*	*75*	*75*	*H*	*M*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*L*	*-*
CLO-2 :	*Recognize the different power amplifiers*	*2*	*75*	*75*	*H*	*M*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*L*	*-*
CLO-3 :	*Design oscillators and multivibrators*	*3*	*75*	*75*	*H*	*M*	*H*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*L*	*-*
CLO-4 :	*Apply different operational amplifiers*	*2*	*75*	*75*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*L*	*-*
CLO-5 :	*Evaluate filters and converter circuits*	*3*	*75*	*75*	*H*	*L*	*H*	*M*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*L*	*-*
CLO-6 :	*Demonstrate various electronic circuits for real time applications*	*2*	*75*	*75*	*H*	*M*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*L*	*-*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*BJT -Biasing methods -Base bias, base bias with emitter feedback*	*Power amplifiers – Types. Determination of efficiency for class A and class B power amplifiers*	*Oscillators and classification of oscillators*	*Introduction to Linear Integrated Technology*	*Filters basics and types*
	SLO-2	*Base bias with collector feedback and voltage divider bias*	*Frequency response of RC coupled class A amplifier*	*Design and Analysis of RC Phase shift oscillator.*	*Fabrication process for Integrated Circuits*	*Design of I and II Order LPF*
S-2	SLO-1	*Emitter bias using BJT in CE configuration*	*Frequency response of Transformer coupled class A amplifier*	*Operation of Hartley's oscillator*	*DC characteristics of op amp and input bias current.*	*Design of I Order HPF*
	SLO-2	*Transistor biasing stability using BJT in CE configuration*	*Operation of Class B push pull power amplifier*	*Analysis of Hartley's oscillator*	*Input offset voltage, Thermal Drift*	*Design of II Order HPF*
S-3	SLO-1	*Operation of BJT as an amplifier.*	*Operation of Differential amplifier*	*Operation of Armstrong oscillator*	*AC characteristics of op-amp and Frequency Response characteristics*	*Design of BPF and BRF*
	SLO-2	*CE, CB, CC Amplifier –Evaluation of h parameters*	*Analysis of Differential amplifier*	*Operation of UJT Relaxation oscillator*	*Frequency compensation and Slew rate*	*Switched variable filters and state variable filters*
S-4	SLO-1	*Small signal analysis of CE Amplifier*	*Self – biased active load differential amplifier*	*Operation of Cross coupled Oscillator*	*Inverting amplifier and Non-inverting amplifier*	*Oscillators- Wein bridge Oscillator using IC 741*
	SLO-2	*Small signal analysis of CB and CC amplifier*	*Source degenerated common source amplifier*	*Integrators*	*Summer and Subtractor*	*Amplitude control and Quadrature control Oscillator*
S-5	SLO-1	*Large signal analysis of CE Amplifier*	*Classification of class C power amplifiers (Tuned amplifiers)*	*Differentiators*	*Voltage follower and ac amplifiers*	*Introduction to simple MOSFET based op amp circuits*
	SLO-2	*Large signal analysis of CB and CC amplifier*	*Frequency response of Single , Double and Staggered Tuned Class C power amplifiers*	*Schmitt trigger*	*V to I and I to V converters*	*Analog to Digital converters and classification*
S-6	SLO-1	*JFET - CS Amplifier - Operation*	*Cascode and Cascaded circuits*	*Multivibrator and classification of multivibrators. Operation of Astable Multivibrator.*	*Instrumentation amplifier*	*Counter type ADC*
	SLO-2	*CS Amplifier – small signal analysis*	*Feedback amplifiers - Barkhausen criterion*	*Analysis of Astable Multivibrator*	*Log and Antilog amplifiers*	*Sigma Delta type ADC*

			and Types of feedback amplifier			
S-7	SLO-1	*JFET - CD Amplifier - Operation*	*Analysis of voltage series feedback amplifier*	*Operation of Monostable Multivibrator.*	*Comparators and classification of comparators.*	*Successive approximation type ADC*
	SLO-2	*Small signal analysis of MOSFET*	*Analysis of voltage shunt feedback amplifier*	*Analysis of Monostable Multivibrator.*	*Applications of Comparators*	*Digital to Analog converters*
S-8	SLO-1	*Biasing of MOSFET*	*Analysis of current series amplifier*	*Operation of Bistable Multivibrator.*	*Basics of IC 555 Timer and Pin Details*	*Pulse width modulator DAC*
	SLO-2	*CD Amplifier – small signal analysis*	*Analysis of current shunt feedback amplifier*	*Analysis of Bistable Multivibrator.*	*Astable operation using IC 555 Timer with applications*	*R -2R Ladder DAC*
S-9	SLO-1	*Problems on biasing of circuits*	*Problems on power amplifiers*	*Voltage and time-based circuits.*	*Monostable operation using IC 555 Timer with applications*	*Inverted R-2R Ladder DAC*
	SLO-2	*Problems on hybrid parameters*	*Problems on feedback amplifiers*	*Series and shunt voltage regulator*	*Voltage regulator using IC 723*	*Binary coded DAC*

Learning Resources	1. *Jacob Millman, Christos C.Halkias, Satyabrata Jit, Millman's Electronic Devices and Circuits, 4th ed., Tata McGraw Hill, 2015* 2. *Boylestead, Nashelsky, Electronic Devices and Circuit Theory, 11th ed., Pearson, 2015* 3. *David A. Bell, Electronic Devices and Circuits, 5th ed., PrenticeHall, 2004*	4. *Sergio Franco, Design with operational amplifiers and Analog Integrated circuits, 5th Edition, McGraw-Hill, 2014* 5. *Roy Choudhary and Shail Jain, Linear Integrated Circuits, 4th ed., New Age International Publishers, 2014.* 6. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/syllabus/*

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
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Course Code	18EEO303T	Course Name	ELECTRICAL MATERIALS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of electrical materials*
CLR-2 :	*Describe conducting and dielectric materials*
CLR-3 :	*Explore knowledge on the insulating and magnetic materials*
CLR-4 :	*Acquire knowledge on superconducting materials*
CLR-5 :	*Interpret opto phenomena on electrical materials*
CLR-6 :	*Enrich the students on different electrical materials and its applications*

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 :	*Outline the electrical and electronics materials, their importance, classification and operational requirement*	*2*	*80*	*75*
CLO-2 :	*Obtain knowledge on conducting and dielectric materials used in engineering application*	*2*	*80*	*75*
CLO-3 :	*Gain idea on insulators and magnetic materials used in engineering, their properties and classification*	*2*	*80*	*75*
CLO-4 :	*Define the phenomenon superconductivity, super conducting materials and their application in engineering*	*2*	*80*	*75*
CLO-5 :	*Understand optical characteristics of conducting and non-conducting electrical materials*	*2*	*80*	*75*
CLO-6 :	*Summarize the different electrical materials and its applications*	*2*	*80*	*75*

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*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
H	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
H	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
H	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
H	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-
H	*L*	*L*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Importance of materials*	*Types of conducting materials*	*Insulating materials– Ceramic, Mica, Porcelain, Glass, Micanite and Glass bonded mica*	*Concept of superconductors*	*Introduction to Thermoplastics*
	SLO-2	*Classification of electrical and electronic materials*	*Low resistivity materials, High resistivity materials*	*Insulating material applications*	*Meaning of phenomenon of superconductivity*	*Introduction to Rubbers*
S-2	SLO-1	*Scope of electrical and electronic materials*	*Contact materials*	*Polymeric materials – Bakelite, Polyethylene. Natural and synthetic rubber and paper*	*Properties of superconductors*	*Introduction to Thermosets*
	SLO-2	*Requirement of Engineering materials*	*Fusible materials*	*Choice of solid insulating material for different applications*	*Types of superconductors*	*DC and AC properties of plastics*
S-3	SLO-1	*Classification of solids on the basis of energy gap*	*Filament materials*	*Liquid insulating materials requirements*	*Critical magnetic field*	*Mechanical properties and processing of plastic*
	SLO-2	*Types of engineering materials, Levels of material structure*	*Carbon as filamentary and brush material*	*Transformer oil, Bubble theory, Aging of mineral insulating oils.*	*Critical temperature*	*Materials for Opto – Electronic Devices - Introduction*
S-4	SLO-1	*Spintronic and its materials*	*Material for conductors, cables,*	*Gaseous insulating Materials – Air*	*Effects of Isotopic mass on critical temperature*	*Optical phenomena*
	SLO-2	*Ferromagnetic semiconductors, Left handed materials*	*Material for wires, solder, sheathing and sealing*	*Gaseous insulating Materials –Nitrogen, Vacuum*	*Silsbee rule*	*Reflection and Refraction*
S-5	SLO-1	*Conductor materials*	*Introduction to dielectric materials*	*Origin of permanent magnetic dipole, Magnetic terminology,*	*Depth of penetration*	*Transmittivity and Scattering,*
	SLO-2	*Factors affecting conductivity*	*classification of dielectric materials*	*Relation between relative permeability and magnetic susceptibility*	*Coherence length*	*Optical absorption*
S-6	SLO-1	*Thermal conductivity*	*Dielectric constant*	*Classification of magnetic materials - Diamagnetic, Paramagnetism, Ferromagnetism*	*Ideal and Hard superconductors*	*Optical properties of non-metals*
	SLO-2	*Heating effect of current*	*Dielectric strength and Dielectric loss*	*Anti-ferromagnetism and the*	*Mechanism of super conduction*	*Optical properties of metals*

				corresponding materials		
S-7	SLO-1	*Thermoelectric effect*	*Polarization, Mechanisms of polarization*	*Ferrimagnetism and ferrites properties and applications*	*London's theory for Type I superconductors, GLAG theory for Type I superconductors*	*Optical properties of semiconductors*
	SLO-2	*Seebeck effect*	*Comparison of different polarization process*	*Ferrimagnetism and ferrites applications*	*BCS theory, Applications and limitations*	*Penetration depth and absorption coefficient*
S-8	SLO-1	*Thomson effect*	*Factors affecting polarization*	*Soft and hard ferrites. Curie temperature*	*Applications of high temperature superconductors*	*Optical properties of insulators*
	SLO-2	*Thomson effect's application*	*Spontaneous polarization*	*Laws of magnetic materials.*	*Superconducting solenoids and magnets*	*Luminescence*
S-9	SLO-1	*Wiedemann – Franz law*	*Behaviour of polarization under impulse and frequency switching*	*Magnetization curve, Initial and maximum permeability*	*MRI for medical mechanism*	*Opto – Electronic devices, Photoconductivity*
	SLO-2	*Lorentz relation*	*Decay and build-up of polarization under ac field*	*Hysteresis loop and loss, Eddy current loss*	*MRI for medical diagnostics*	*Photoconductive cell*

Learning Resources	1. *K.M. Gupta Nishu Gupta, Advanced Electrical and Electronics Materials; Processes and Applications, Wiley, First Edition, 2015* 2. *R.K. Shukla, Archana Singh, Electronic Engineering Materials, McGraw Hill, 2012* 3. *Solymar, Electrical Properties of Materials, Oxford , 9th Edition, 2014*	4. *A.J. Dekker, Electrical Engineering Materials, Pearson, 2016* 5. *S.O. Kasap, Principle of Electronic Materials and Devices , McGraw Hill, 3rd Edition, 2010* 6. *https://nptel.ac.in/courses/122102008/36*

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		
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Course Code	18EEO304T	Course Name	POWER PLANT ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical and Electronics 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 overview on power generation through various methods*			
CLR-2 :	*Gain knowledge of power plant measurements and devices*			
CLR-3 :	*Categorize the various analyzer In Power Plants*			
CLR-4 :	*Get detailed knowledge on Nuclear power plant*			
CLR-5 :	*Outline the concept of Renewable energy*			
CLR-6 :	*Educate various concept in conventional and non-conventional resources*			

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 :	*Familiarize about different power generation process*	*2*	*80*	*75*
CLO-2 :	*Understand the various measurement techniques in power plant*	*3*	*80*	*75*
CLO-3 :	*Analyze important parameter for control of power plant*	*3*	*80*	*75*
CLO-4 :	*Summarize the working of Nuclear Reactor*	*3*	*80*	*75*
CLO-5 :	*Employ the acquired knowledge of Renewable energy in power plant*	*3*	*80*	*75*
CLO-6 :	*Gain knowledge on various concepts related to Power Plant Engineering*	*3*	*80*	*75*

		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 :	*Familiarize about different power generation process*	*H*	-	-	-	-	-	*H*	-	-	-	-	-	*H*	*M*	*H*
CLO-2 :	*Understand the various measurement techniques in power plant*	*H*	*M*	-	-	-	-	*M*	*M*	-	-	-	-	*M*	*M*	*M*
CLO-3 :	*Analyze important parameter for control of power plant*	*H*	*M*	-	-	-	-	*M*	*M*	-	-	-	-	*H*	*M*	*M*
CLO-4 :	*Summarize the working of Nuclear Reactor*	*H*	*M*	-	-	-	-	*M*	*M*	-	-	-	-	*H*	*H*	*M*
CLO-5 :	*Employ the acquired knowledge of Renewable energy in power plant*	*H*	-	-	-	-	-	*M*	*M*	-	-	-	-	*H*	*M*	*M*
CLO-6 :	*Gain knowledge on various concepts related to Power Plant Engineering*	*H*	*M*	-	-	-	-	*M*	*M*	-	-	-	-	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Brief survey of methods of power generation*	*Electrical measurements: Current, Voltage*	*Introduction of Flue gas*	*Basics of Nuclear Engineering*	*Hydro Electric Power Plants*
	SLO-2	*Thermal power*	*Power, Frequency, Power factor*	*oxygen analyzer*	*Layout and subsystems of Nuclear Power Plants*	*Elements of Hydro-electric power plant*
S-2	SLO-1	*Overview of Nuclear*	*Non– electrical parameters: Flow of feed water*	*Analysis of impurities in feed water*	*Fission reactions*	*Types of Dams*
	SLO-2	*Solar and Wind power*	*Flow of feed fuel*	*Analysis of impurities in feed steam*	*Working of Nuclear Reactors*	*classification of Hydro-electric power plants*
S-3	SLO-1	*Importance of instrumentation in power generation*	*Flow of feed air*	*Dissolved oxygen analyzer*	*Classification of Reactors*	*Hydro sources and power plants Energy strategies*
	SLO-2	*Factors affecting power plant*	*Steam pressure*	*Dissolved oxygen analyzer working principle*	*Nuclear reactor control loops*	*Size of the plant and choice of units*
S-4	SLO-1	*Building blocks for all types of power generation plants*	*Steam temperature*	*Methods of measuring dissolved oxygen*	*reactor dynamics*	*Typical Layout and associated components including Turbines*
	SLO-2	*Hydro and Thermal power plant*	*Drum level measurement*	*Chromatography-principles-applications*	*Boiling Water Reactor (BWR)*	*Turbine Governing*
S-5	SLO-1	*Building blocks for all types of power generation plants*	*Radiation detector*	*Types of Chromatography- Gas Chromatography*	*Pressurized Water Reactor (BWR)*	*Comparison of hydro and steam power plant*
	SLO-2	*Nuclear- Solar power*	*Smoke density measurement*	*Liquid Chromatography*	*CANada Deuterium-Uranium reactor (CANDU), Breeder*	*Cost of Hydroelectric Power Plant*
S-6	SLO-1	*Building blocks for all types of power generation plants-wind power*	*Dust monitor*	*PH meter*	*Gas Cooled Reactor*	*Principle, Construction and working of Wind energy*
	SLO-2	*Tidal power plant*	*flame monitoring*	*PH meter-design and working principle*	*Liquid Metal Cooled Reactor*	*Principle, Construction and working of tidal energy and Types of tidal power plants*
S-7	SLO-1	*Details of boiler process*	*speed vibration*	*Classifications of Analyzer*	*Economics of Nuclear Power Plants*	*Solar Photo Voltaic cell (SPV)*

	SLO-2	*P&I diagram of boiler*	*shell temperature*	*Fuel analyzer*	*Nuclear power plant in India*	*Solar thermal power systems use concentrated solar energy*
S-8	SLO-1	*Piping diagram of boiler*	*pedestal vibration*	*Portable fuel property analyzer*	*Uranium Enrichment*	*Geo Thermal power plants - types*
	SLO-2	*Instrumentation diagram of boiler*	*shaft vibration*	*Natural Gas analyzer*	*instrumentation diagram of different types of nuclear power plant*	*Biogas Photosynthesis and origin of biogas energy*
S-9	SLO-1	*Power plant performance efficiency*	*eccentricity measurement*	*Pollution monitoring instruments*	*Control Safety measures for Nuclear Power plants*	*Biogas energy resources*
	SLO-2	*Cogeneration system*	*temperature monitoring & control*	*Pollution control technologies*	*Waste Disposal Options for Coal and Nuclear Power Plants*	*Fuel Cell power systems*

Learning Resources	*1. K. Krishnaswamy, M. Ponnibala, Power Plant Instrumentation, PHI Learning Pvt Ltd.,2013.* *2. Philip Kiameh, Power Plant Instrumentation and Controls, McGraw-Hill Professional, 2014.* *3. David Lindsley, Power-plant Control and Instrumentation: The Control of Boilers and HRSG Systems, IET, London, 2000.*	*4. G. F. Gilman, Jerry Gilman, Boiler Control Systems Engineering, ISA, 2010.* *5. G.R.Nagpal, Power Plant Engineering,khanna Publisher ,2005* *6. M.M. El-Wakil, Power Plant Engineering, Tata McGraw – Hill Publishing Company Ltd., 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

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2.Mr Ramanavasu, Bhavini, ramanavasu@igcar.gov.in	*2.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*2.Dr.S.Padmini, SRMIST*

Course Code	18EEO305T	Course Name	ELECTRICAL DRIVES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Enrich the students on the basics of electric drives*
CLR-2 :	*Learn the concepts of DC motor drives and its speed control*
CLR-3 :	*Familiarize the power electronic based speed control of induction motor drives*
CLR-4 :	*Get an idea of speed control of synchronous motor*
CLR-5 :	*Understand the basic of digital speed control techniques*
CLR-6 :	*Get an idea about selection of drives and control schemes*

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 knowledge on the concept of electric drives*	*2*	*80*	*75*	*H*	*L*	*L*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Analyze the concept & characteristics of dc motors*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Interpret of speed-control of induction motors*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Get detailed knowledge on synchronous motor drives*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Apply the digital speed control techniques for various drives*	*2*	*80*	*75*	*H*	*M*	*L*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Apply the drives and control schemes for real time applications*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Electric drives - Advantage of electric drives*	*DC Motor Drives:-Introduction*	*Induction motor drives-Introduction*	*Synchronous motor drives – introduction*	*Digital technique in speed control*
	SLO-2	*Block diagram of electric drives*	*DC motor and their performance*	*Advantages and Disadvantages*	*Synchronous Motor Drives*	*Advantages of digital techniques*
S-2	SLO-1	*Selection of motor power rating*	*Braking methods*	*Stator control of IM*	*Speed control of synchronous motors*	*Limitations of digital techniques*
	SLO-2	*Thermal Modeling*	*Ward Leonard drives*	*Stator voltage control*	*Synchronous motors – Frequency control*	*Speed control system with multirate sampling*
S-3	SLO-1	*Thermal model of motor for heating and cooling*	*Transformer fed DC drive*	*Stator Frequency control*	*Synchronous motors – Start with Prime mover & damper winding*	*Microprocessor based control - introduction*
	SLO-2	*Thermal model of motor for heating and cooling - derivation*	*Uncontrolled rectifier fed DC drive*	*Stator Frequency control – advantages and disadvantages*	*Synchronous motors –damper winding*	*Microprocessor based control of DC drive*
S-4	SLO-1	*Classes of motor duty cycle*	*Single phase half controlled rectifier fed DC drives - operation*	*V/F control*	*Voltage Source Inverter fed synchronous motor*	*Microprocessor based control of induction motor drive*
	SLO-2	*Determination of motor rating*	*Single phase half controlled rectifier fed DC drives - derivation*	*Closed loop V/F control*	*Chopper fed VSI with synchronous motor*	*Microprocessor based control of synchronous motor drive*
S-5	SLO-1	*Control of electric drives*	*Single phase fully controlled rectifier fed DC drive- operation*	*Cycloconverter - introduction*	*Current Source Inverter fed synchronous motor*	*Selection of drives for paper mill*
	SLO-2	*Modes of operation*	*Single phase fully controlled rectifier fed DC drive- derivation*	*Cycloconverter fed induction motor drive*	*Chopper fed CSI with synchronous motor*	*Control schemes for paper mill*
S-6	SLO-1	*Speed control of electric drives*	*Chopper - introduction*	*VSI Inverter fed induction motor drives*	*Cycloconverter fed synchronous motors*	*Selection of drives for steel rolling mill*
	SLO-2	*Drive classifications*	*Chopper controlled DC drives*	*Comparison: VSI and CSI*	*Limitations - Cycloconverter fed synchronous motors*	*Control schemes for steel rolling mill*
S-7	SLO-1	*Closed loop control of drives*	*Time ratio control*	*Rotor control*	*Self control*	*Selection of drives for lift*
	SLO-2	*Speed, torque and current control*	*Current limit control*	*Rotor resistance control*	*Separate control*	*Control schemes for lift*
S-8	SLO-1	*Multiquadrant operation of electrical drive*	*Single, two quadrant operations*	*Slip power recovery schemes*	*Open loop operation of synchronous drive*	*Selection of drives for crane*

	SLO-2	*Torque equation for rotating system*	*Four quadrant operation*	*Static Kramer & static scherbius scheme*	*Closed loop operation of synchronous drive*	*Control schemes for crane*
S-9	SLO-1	*Speed torque characteristics*	*Simulation of 1-phase rectifier fed DC motor*	*Simulation of three phase VSI using SPWM*	*Closed loop operation of power factor control*	*FPGA based control of electric drives*
	SLO-2	*Applications of electric drives*	*Simulation of 3-phase rectifier fed DC motor*	*Simulation of three phase VSI using pulse generator*	*Applications synchronous drive*	*Application of Digital technique in speed control*

Learning Resources	*1. G. K. Dubey, Fundamentals of Electrical Drives, Second Edition, CRC Press, 2010.* *2. R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Second Edition, Prentice Hall, 2008.*	*3. W. Leonhard, Control of Electric Drives, Springer Science & Business Media, Third Edition, 2001.* *4. https://onlinecourses-archive.nptel.ac.in/.*

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
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Course Code	18EEO306T	Course Name	ENERGY CONSERVATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Outline the concepts of world energy scenario in industries*
CLR-2 :	*Describe the basics of electrical system*
CLR-3 :	*Impart knowledge on various methods of improving energy efficiency in industries*
CLR-4 :	*Give an overview about the energy policies, energy planning and policy making in India*
CLR-5 :	*Provide an understanding of the basics of energy conservation method and energy auditing in industries*
CLR-6 :	*Create overall structure of energy conservation starting from environmental aspects to energy management 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 :	*Gain knowledge of world energy scenario*	*2*	*75*	*75*
CLO-2 :	*Understand the concepts of electrical system*	*3*	*75*	*75*
CLO-3 :	*Assess the energy efficiency in industrial system*	*3*	*75*	*75*
CLO-4 :	*Analyse the energy policies, energy planning and policy making in india*	*3*	*75*	*75*
CLO-5 :	*Correlate with various methods of energy conservation*	*3*	*75*	*75*
CLO-6 :	*Implement energy conservation methods and laws to save energy*	*3*	*75*	*75*

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*
H	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	*M*
H	-	-	-	-	-	*H*	*H*	-	-	-	-	*M*	*H*	*M*
H	-	-	-	-	-	*L*	*H*	-	-	-	-	*M*	*M*	*H*
H	-	-	-	-	-	*L*	*H*	*M*	*M*	-	-	*M*	*H*	*M*
H	-	-	-	-	-	*M*	*H*	*M*	*M*	-	-	*M*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Energy classificatios*	*Introduction Electrical Systems*	*Air condition and refrigeration*	*Introduction to energy policy*	*Investment - need, appraisal and criteria*
	SLO-2	*Power Past & Present scenario of World*	*Electrical network types and classifications*	*Diesel Generator*	*National energy policy in the last plan periods*	*Financial analysis techniques*
S-2	SLO-1	*Sectorial energy consumption*	*HT supply*	*Energy Efficiency in Building*	*ISO-50001, PDCA, PAT scheme*	*Simple payback period*
	SLO-2	*domestic, industrial and other sectors*	*LT supply*	*Energy Efficiency in Building*	*BEE & State Development Agencies & EESL Programmes*	*Return on investment*
S-3	SLO-1	*energy needs of growing economy, energy intensity*	*Transformers and its operation*	*Savings opportunities in HVAC*	*Municipal & Agriculture DSM Initiatives*	*Net present value, internal rate of return, cash flows*
	SLO-2	*long term energy scenario, energy pricing*	*Types of transformer*	*Fans and blowers*	*Energy use and Energy supply*	*Net present value, internal rate of return, cash flows*
S-4	SLO-1	*energy security, energy conservation*	*Cables – and its construction*	*Conservation opportunities*	*Overview of renewable energy policy and the Five Year Plan programme*	*Risk and sensitivity analysis*
	SLO-2	*energy conservation importance, energy strategy for the future*	*Types and Cable Sizing*	*Pumps - CASE STUDY*	*Standards and Labelling Programme EEC initiatives in Other Sectors*	*Financing options*
S-5	SLO-1	*National Energy consumption Data*	*Concept of Capacitors*	*Control strategies*	*Basic concept of Input-Output analysis*	*Energy performance contracts and role of Energy Service Companies (ESCOs)*
	SLO-2	*Energy Pricing*	*Types of Capacitors*	*Conservation opportunities*	*Concept of energy multiplier and Implication of energy multiplier for analysis of regional and national energy policy Organizational structure*	*Energy Monitoring*
S-6	SLO-1	*Environmental aspects associated with energy utilization*	*Power Factor Improvemen*	*Cooling Tower -performance*	*key developments and changes in India's energy policies and planning in the context of energy efficiency and environmental concerns*	*Targeting: Defining monitoring & targeting*

	SLO-2	*Environmental aspects associated with energy conservation*	*Harmonics*	*Efficient system operation*	*key developments and changes in India's energy policies and planning in the context of energy efficiency and environmental concerns*	*Targeting: Defining monitoring & targeting*
S-7	SLO-1	*Energy Auditing: Needs, Types,*	*Electric Motors – Motor Efficiency Computation*	*Efficient system operation*	*regulatory frameworks and reforms across various energy sectors*	*elements of monitoring & targeting*
	SLO-2	*Methodology and Barriers*	*Energy Efficient Motors*	*Validation of energy saving using application software*	*regulatory frameworks and reforms across various energy sectors*	*Data and information-analysis, techniques*
S-8	SLO-1	*Role of Energy Managers*	*Illumination – Lux, Lumens*	*Energy saving opportunities*	*Energy Policies success stories, failures*	*Energy consumption*
	SLO-2	*Needs of Energy Managers*	*Types of lighting, Efficacy*	*Energy saving opportunities*	*Energy saving potential of technology*	*Production, cumulative sum of differences (CUSUM).*
S-9	SLO-1	*Instruments for energy auditing*	*LED Lighting And types*	*Assessment of cooling towers*	*Energy tariffs and Energy Instrument*	*Energy Management Information Systems (EMIS)*
	SLO-2	*Energy conservation*	*Scope Of Encon In Illumination*	*Assessment of cooling towers*	*CASE STUDY for energy tariffs in industry*	*Energy Management Information Systems (EMIS)*

Learning Resources	*1. Witte. L.C., P.S. Schmidt, D.R. Brown, Industrial Energy Management and Utilisation, Hemisphere Publ, Washington, 1988* *2. Callaghn, P.W. Design and Management for Energy Conservation, Pergamon Press, Oxford, 1981* *3. Energy Manager Training Manual (4 Volumes) available at www.energymanager training.com, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India, 2004*	*4. R Loulou, P R Shukla and A Kanudia, Energy and Environment Policies for a sustainable Future, Allied Publishers Ltd, New Delhi, 1997* *5. Handbook on Energy Efficiency, TERI, New Delhi, 2001* *6. https://www.edx.org/course/incorporating-renewable-energy-in-electricity-grids-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	*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
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2. Mr. N. Saravanan, Engineering Manageer Electrical, L&T Ltd, n-saravanan@lntecc.com	*2. Dr.Ruben sudhakar D, NIT-Trichy, rubensudhakar@nitt.edu*	*2. Dr. D. Sattianadan, SRMIST*

Course Code	18EEO307T	Course Name	ELECTRICAL POWER UTILIZATION AND ILLUMINATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Outline the basic concepts of conventional and modern electric heating methods used for various applications*
CLR-2 :	*Impart knowledge on fundamentals of illumination technology and design the lighting schemes*
CLR-3 :	*Educate the students on electroplating , electrodeposition and electroforming*
CLR-4 :	*Enumerate the concept of electric traction systems and braking methodologies*
CLR-5 :	*Understand and analyze the working of electric-hybrid vehicles and design the illumination schemes for smart building .*
CLR-6 :	*Create a deep knowledge on the electric power utilization and model the illumination schemes*

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 :	*Understand electric heating, welding and implement the modern methodologies for various applications*	*2*	*80*	*75*
CLO-2 :	*Gain knowledge on basic laws of illumination and design the lighting system*	*3*	*80*	*75*
CLO-3 :	*Apply the various process like electroplating, electrolysis and electroforming for modern applications*	*2*	*80*	*75*
CLO-4 :	*Interpret the design of electric traction systems*	*3*	*80*	*75*
CLO-5 :	*Obtain an in depth knowledge on the concepts of electric, hybrid vehicles and model the lighting schemes for smart building*	*3*	*80*	*75*
CLO-6 :	*Design a illumination schemes for buildings along with a in depth knowledge of power utilization concepts*	*3*	*80*	*75*

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
M	*M*	*M*	-	-	-		-	-	-	-	-	*M*	*M*	-
H	*H*	*H*	*H*	*M*	-	*M*	*M*	-	-	-	-	*M*	*M*	*M*
M	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*M*	*M*	-	-	-	*M*	-	-	-	-	*M*	*M*	*M*
H	*H*	*M*	*M*	*M*	-	*M*	*M*	-	-	-	-	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Principle of heating, modes of transfer*	*Review of laws of illumination*	*Fundamental principles of extraction*	*Electric Traction*	*History of electric and hybrid vehicles*
	SLO-2	*Methods of Electrical Heating*	*Luminous efficacy*	*Refining of metals*	*Traction Principles*	*Vehicle motion*
S-2	SLO-1	*Types of electric furnance: resistance*	*Lighting Calculations*	*Electroplating concepts*	*Types of traction systems*	*Dynamic equation for the vehicle*
	SLO-2	*Arc, dielectric furnance*	*Lighting sources and its types*	*Methods of electroplating*	*Services and supply systems for traction*	*Configuration of electrical vehicles*
S-3	SLO-1	*Microwave, induction heating*	*Lighting sources in domestic application*	*Estimation of power and current for depositing metals*	*Traction motor characteristics*	*Tractive effort, force and gear ratio for electric vehicle*
	SLO-2	*Eddy current heating*	*Street Lighting*	*Factors affecting electro deposition process*	*equation of train motion*	*Transmission requirement for electric cars*
S-4	SLO-1	*Types of welding: Arc*	*Industrial lighting*	*Electrolysis process and its chemistry*	*Speed time curve*	*Vehicle performance analysis*
	SLO-2	*Resistance welding*	*Indoor lighting*	*Electrodes,*	*Energy and specific energy consumption*	*Energy consumption*
S-5	SLO-1	*Air conditioning working*	*Outdoor lighting*	*Cell.potential, Emf of Galvanic cell*	*Quantitative analysis of speed time curve*	*Drives for Electric cars*
	SLO-2	*Different types of Air conditioning system*	*Design of lighting*	*Nernst equation*	*Quantitative analysis of energy consumption for drives used in traction*	*Braking*
S-6	SLO-1	*Heating of buildings.*	*light pollution and light trespass*	*Concept of equilibrium in electrochemical cells*	*Quantitative analysis of specific energy consumption*	*Control equipments of electric car*
	SLO-2	*Power supply for heating and welding*	*photometry Energy consideration*	*Faradays law of electrolysis*	*Tramways*	*Auxillary equipments*
S-7	SLO-1	*comparison of types of heating and welding*	*IES,ANSI STANDARDS for Lighting schemes*	*Electroforming process*	*Railways trolley buses*	*Introduction to smart buildings*
	SLO-2	*Quantitative analysis of Electric heating*	*Polar curves of different types of sources*	*Modern applications of electroplating,*	*Riding index*	*Design of lighting schemes in smart building*
S-8	SLO-1	*Quantitative analysis of welding*	*Rousseau's Construction*	*Applications of Electrolysis and Electroforming*	*Quantitative analysis of Riding index*	*Intelligent illuminance control in smart building*
	SLO-2	*Modern trends in electric heating*	*Quantitative analysis of illumination*	*Applications of Electroforming*	*Disadvantages of conventional traction over modern days drive*	*Quantitative analysis of electric vehicle tractive force calculations*
S-9	SLO-1	*Modern trends in welding process*	*Energy efficient*	*Difference between electroplating*	*Introduction to green energy for traction*	*Quantitative analysis on gear ratio*

				electroforming and electrolysis		
	SLO-2	*Applications of heating and welding*	*Lighting scheme of the building using simulation tools*	*Electroplating design tools*	*Pros and cons of electric and non electric traction system*	*Quantitative analysis on efficiency calculations*

Learning Resources	*1. S.Sivanagaraju,M.Balasubba Reddy,D.Srilatha, Generation and Utilization of Electrical energy, Pearson publication,2010.* *2. Wadhwa C.L., Generation, Distribution and Utilization of Electrical Energy, New Age International publishers, 3rd edition, 2010.*	*3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.* *4. G.C.Garg, Utilization ofElectric Powerand Electric Traction, KhannaPublishers, 2006.* *5. https://swayam.gov.in/explorer?ncCode=NPTEL*

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. A.Kannan, Seshasayee paper and board limited akannan@sbppapers.com	*1. Dr. S. Arul Daniel, NIT Trichy, daniel@nitt.edu*	*1. Mrs.R.Rajarajeswari,SRMIST*
2. Dr. P. Dharmalingam, Executive Director, EnsavePvt Ltd, pdlingam@gmail.com	*2. Dr. R.Ramesh, CEG, rramesh@annauniv.edu*	*2. Dr. D.Suchitra, SRMIST*

Course Code	18EEO308T	Course Name	ELECTRICAL POWER SYSTEM	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamentals of power stations*
CLR-2 :	*Understand economics of power generation*
CLR-3 :	*Acquire knowledge on AC power supply schemes and insulators*
CLR-4 :	*Understand the basics of substations*
CLR-5 :	*Understand the design of cables and protection equipments*
CLR-6:	*Acquire knowledge of transmission lines and cables*

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 :	*Understand the various aspects of power station*	*1*	*75*	*75*
CLO-2 :	*Execute the performance of transmission lines*	*2*	*75*	*75*
CLO-3 :	*Summarize the AC power supply schemes and DC power transmission*	*2*	*75*	*75*
CLO-4 :	*Analyse the transmission substation and grounding*	*2*	*75*	*75*
CLO-5 :	*Enrich the types of cables and protection equipments*	*1*	*75*	*75*
CLO-6 :	*Understand the supply systems, design of transmission lines and cables*	*2*	*75*	*75*

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*	-	-
H	*L*	-	-	-	-	*M*	-	-	-	-	-	*M*	-	-
H	*L*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
H	*M*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
H	*H*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
H	*H*	-	-	-	-	*M*	-	-	-	-	-	*M*	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Importance of Electrical Energy*	*Structure of Electric Supply System*	*Typical AC power supply scheme*	*Introduction to substation*	*Underground cables*
	SLO-2	*Generation of Electrical Energy*	*Variable load on power station*	*Types of power transmission*	*Classification of substation*	*Construction of cables*
S-2	SLO-1	*Sources of Energy*	*Types of loads*	*Comparison of DC and AC transmission*	*Comparison between outdoor and indoor sub stations*	*Properties of insulation materials*
	SLO-2	*Comparison of Energy Sources, Units of Energy*	*Load curves and selection of generating units*	*Advantages of high transmission voltage*	*Step up substation*	*Insulation materials for cables*
S-3	SLO-1	*Relationship among energy units*	*Base load and peak load on power station*	*Limitations of high transmission voltage*	*Primary grid substation*	*Classification of cables*
	SLO-2	*Arrangement of Steam Power Station*	*Methods of meeting the load*	*Elements of a transmission line*	*Secondary substation*	*Switchgear*
S-4	SLO-1	*Choice of site and Equipment's of Steam Power Stations*	*Economics of power generation*	*Economics of power transmission,*	*Distribution substation*	*Essential features of switchgear*
	SLO-2	*Hydro – electric Power Station*	*Cost of electrical energy*	*Economic choice of conductor size*	*Symbols for equipment in sub station*	*Faults in power system*
S-5	SLO-1	*Choice of site and Equipment's of Hydro Power Stations*	*Objective of tariff*	*Economic choice of Transmission voltage*	*Equipments in a substation*	*Circuit breakers*
	SLO-2	*Diesel Power Station*	*Characteristics of tariff*	*Requirements of satisfactory electric power*	*Key diagram of a substation*	*Arc phenomenon*
S-6	SLO-1	*Nuclear Power Plant*	*Types of tariff*	*Main components of overhead lines*	*Need for grounding*	*Types of circuit breakers*
	SLO-2	*Connected load, Maximum demand, Average load*	*Types of power factor tariff*	*Conductor materials*	*Grounding equipments*	*Need for Fuses*
S-7	SLO-1	*Calculation of Load duration curve, Types of loads*	*Power factor*	*Line supports*	*System grounding*	*Characteristics of fuse element*
	SLO-2	*Load curves and selection of generating units*	*Power triangle*	*Types of Insulators*	*Neutral grounding*	*Fuse element materials*
S-8	SLO-1	*Energy, power, efficiency calculations of conventional power plant*	*Disadvantages of low power factor*	*Factors affecting Transmission*	*Advantages of neutral grounding*	*Types of Fuses*
	SLO-2	*Basic layout of sustainable energy resources –Photovoltaic system*	*Causes of low power factor*	*Constants of a transmission line*	*Voltage surge*	*Low voltage fuses*

S-9	SLO-1	*Wind energy*	*Power factor improvement- static capacitor*	*Resistance of a transmission line*	*Causes of over voltages*	*High voltage fuses*
	SLO-2	*Different operating voltages of generation, transmission and distribution*	*Synchronous condenser*	*Inductance of a transmission line*	*Internal causes of overvoltages*	*Difference between a fuse and circuit breaker*

Learning Resources	*1. C.L.Wadhwa, Electrical Power systems, 7th edition, New age international publisher, Delhi 2017* *2. P.S.R. Murty, Electrical Power Systems,1st edition, Butterworth-Heinemann publisher, 2017*	*3. Metha.V.K and Rohit Metha, Principles of Power System, 3rd edition , S.Chand, 2005.* *4. Despande.M.V, Electrical Power Systems Design, 1st edition, Tata McGraw Hill Publishing Company, New Delhi, 2009* *5. https://www.coursera.org/learn/electric-power-systems*

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
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Course Code	18ECO101T	Course Name	SHORT RANGE WIRELESS COMMUNICATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Overview of different modulation scheme and wireless system*
CLR-2 :	*understand the various components used to implement a short-range radio system.*
CLR-3 :	*Analysis of the various kinds of transmitters and receivers used for Short range Wireless Communication.*
CLR-4 :	*know about regulations and standards of ISM band communications*
CLR-5 :	*Design and analysis of short-range radio like UWB and Visible light.*

Course Learning Outcomes (CLO):	*The purpose of this course is to :*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	*cover the various forms of signals used for information transmission and modulation, and overall wireless system properties.*	*2*	*80*	*70*
CLO-2 :	*present various component types that can be used to implement a short-range radio system.*	*2*	*85*	*75*
CLO-3 :	*describe the various kinds of transmitters and receivers.*	*2*	*75*	*70*
CLO-4 :	*covers regulations and standards of ISM band communications*	*2*	*85*	*80*
CLO-5 :	*covers some of the most important new developments in short-range radio like UWB and Visible light.*	*2*	*85*	*75*

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

Duration (hour)		Wireless Systems	Baseband Coding basics	RF transceivers	Wireless standards	Optical wireless Technologies
		9	9	9	9	9
S-1	SLO-1	*Introduction to wireless systems*	*Types of Antennas-Dipole, groundplane, loop*	*RF Receivers- Introduction*	*Technical Background to the WPAN Concept - Regulation and Standardization Issues*	*Fundamentals of UROOF Technologies*
	SLO-2	*Reasons for the Spread of Wireless Applications*	*Helical, Patch antennas*	*RF Source-Frequency control*	*European Consortium: Overview*	*Conversion from RF to Optical Domain*
S-2	SLO-1	*Characteristics of Short-range Radio*	*Antenna Characteristics-Impedence, directivity and gain, Effective area*	*Modulation types*	*Millimeter-Wave Applications and Services - PAN scenarios in the IST Magnet project*	*Conversion from Optical to RF Domain*
	SLO-2	*Wireless Applications*	*Polarization, Bandwidth, Antenna factor*	*Amplifiers*	*Typical LDR services connected to the IST-FP6 MAGNET project*	*Optical Microwave Mixing Used for UWB Over Systems*
S-3	SLO-1	*Elements of Wireless Communication Systems-Transmitter*	*Baseband Data Format and Protocol - Radio Communication Link Diagram*	*Impedance matching in transmitter and receivers*	*Frequency Regulation and Standardization Issues - Optional UM4 usage models issued from the IEEE802.15.3c TG*	*Integrated UROOF Transceiver (IUT)*
	SLO-2	*Elements of Wireless Communication Systems-Receiver*	*Code Hopping*	*Filtering*	*Flexible antenna gain, 60 GHz regulation status for wireless transmissions.*	*Mixed Wireless-wired UROOF Channel, Carrier-to-noise Ratio*
S-4	SLO-1	*Wireless Local Area Networks (WLAN)-WIFI*	*Baseband Coding-Digital systems*	*SAW band pass filter matching*	*Channel Propagation Characterization and Modeling- 60 GHz Propagation Measurements*	*Laser and Photodetector Noise Baseline,*
	SLO-2	*Network Architecture*	*Wireless Microphone System*	*Tuned Radio Frequency (TRF)*	*Propagation Channel Characterization*	*Clipping Distortion Implication , Latency*
S-5	SLO-1	*Bluetooth Transceiver*	*RF Frequency and Bandwidth-factors*	*ASH Receiver*	*Multipath Propagation Modeling*	*Modelling the Propagation through the Fibre*
	SLO-2	*Bluetooth Modes*	*Propagation characteristics*	*Super regenerative Receiver –Block diagram*	*France Telecom Propagation Channel Models*	*Analysis of UWB Technologies for UROOF- Comparing UWB Technologies for Radio-over- fibre*
S-6	SLO-1	*Zigbee Architecture, Frame Structure*	*Modulation types*	*Super regenerative Receiver –*	*MSK-Based System for LOS Gb/s*	*MB-OFDM Over Multimode Fibre*

				Operation	*Communications*	
	SLO-2	*Applications and conflicts*	*Modulation for digital event communication*	*Super heterodyne Receiver-Block diagram*	*System architecture for an MSK-based system to operate in a LOS channel.*	*All-optical Generation of Ultra-wideband Impulse Radio*
S-7	SLO-1	*Ultra-wideband Technology-Bit Sequence detection*	*Continuous Digital Communication*	*Super heterodyne Receiver- Operation*	*OFDM-Based System for NLOS Gb/s Communications*	*Operation Principles and Theoretical Approach*
	SLO-2	*UWB Block Diagram*	*Advanced Digital Modulation*	*Direct Conversion Receiver- Block diagram*	*System architecture for an OFDM-based system to operate in a NLOS channel.*	*VLC Link –Transmitter*
S-8	SLO-1	*Wireless Modules-Japan,UK,USA*	*Spread Spectrum-DHSS*	*Direct Conversion Receiver- Operation*	*System Design Aspects-Channel Plan*	*The VLC Channel*
	SLO-2	*Wireless Modules-Austria, Honeywell, Norway*	*Spread Spectrum-FHSS*	*Digital Receivers-Software radio*	*60 GHz Channel Characteristics, Baseband Modulation: OFDM versus Single Carrier*	*Receiver, Modulation*
S-9	SLO-1	*FCC Regulations-Terms and definitions*	*RFID-transceiver*	*Software radio operation*	*60 GHz Analog Front-End Architectures*	*Potential Applications*
	SLO-2	*Nomenclature for defining Emission, modulation and transmission*	*Design issues for RFID*	*Repeaters*	*Multiple Antenna Technologies*	*Challenges*

Learning Resources	1. *Alan Bensky, "Short range Wireless Communications-Fundamentals of RF system design and Applications", Elsevier Inc, 2004* 2. *Antti V. Raisanen, Arto Lehto, "Radio engineering for wireless communication and sensor applications", Artech House, 2003*	3. *Rolf Kraemer and Marcos Katz, "Short-range wireless communications emerging technologies and applications", Wiley WWRF series, March 2009* 4. *Shlomi Arnon, John Barry, George Karagiannidis, Robert Schober, Murat Uysal, "Advanced Optical Wireless Communication Systems" , Cambridge University Press, 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 %*	-	*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. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. J. Subhashini, SRM IST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18EC0102J	Course Name	ELECTRONIC CIRCUITS AND SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide a basis for understanding semiconductor material, how a pn junction is formed and its principle of operation*
CLR-2 :	*Describe the basic structure, operation and characteristics of transistors BJTs and FETs, and discuss their use as a switch and an amplifier*
CLR-3 :	*Learn the basics of op-amp: the principle, operation, characteristics and fundamentally important circuits*
CLR-4 :	*Describe and analyze the basic operation of sinusoidal oscillators and use a 555 Timer in an oscillator application.*
CLR-5 :	*Learn the fundamentals of analog and digital communication, networking, radio transmission and mobile telephones*
CLR-6 :	*Encourage the learner to assemble and test real circuits in the laboratory*

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 :	*Understand the operation, characteristics, parameters and specifications of semiconductor diodes and demonstrate its important applications*	*1*	*80*	*70*
CLO-2 :	*Review the transistor (BJT & FET) construction, operation, characteristics and parameters, as well as its application in amplification and switching.*	*1*	*80*	*70*
CLO-3 :	*Identify different configurations of op-amp analyze the parameters of op-amp and observe the frequency response of operational-amplifier.*	*1*	*80*	*70*
CLO-4 :	*Understand & demonstrate different applications based on operational-amplifier and special linear ICs*	*1*	*80*	*70*
CLO-5 :	*Understand the basic concepts and techniques of telecommunication systems and networks*	*1*	*80*	*70*
CLO-6 :	*Understand how circuit behavior can be studied with a computer, using a circuit simulation software*	*2*	*90*	*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
L	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
L	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
L	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
L	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
L	*L*	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	*H*	-	*H*	-	-	-	-	*L*	-	*M*	*L*	-	-

		Active Discrete Components & Circuits – I	Active Discrete Components & Circuits – II	Linear Integrated Circuits	Oscillators and Timers	Telecommunications
Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Conduction in semiconductors*	*JFETs: Structure & Operation*	*Introduction to Op-amp*	*RC Phase-Shift oscillator Operation*	*Analog & Digital Communication: Stages in telecommunication systems*
	SLO-2	*Conduction in diodes*	*Characteristics & Parameters*	*Basic op-amp and its characteristics*	*& Design*	*Carriers and Modulation*
S-2	SLO-1	*Basic operation of PN junction diode*	*JFET Biasing (Voltage-Divider Biasing)*	*op-amp modes*	*Wein bridge Oscillator operation*	*Carriers and Modulation*
	SLO-2	*VI Characteristics of diode*	*CS-JFET Amplifier operation*	*parameters*	*& Design*	*Pulse Modulation*
S 3-4	SLO-1	*Lab-1: VI Characteristics of PN Junction Diode*	*Lab-4: Design & Analysis of CE BJT Amplifier*	*Lab-7: Negative Feedback op-amp circuits*	*Lab-10: Analysis & Design of RC Oscillators*	*Lab-13: Demonstration of AM & FM*
	SLO-2					
S-5	SLO-1	*Applications of diode: HWR & FWR*	*MOSFETs: Structure*	*Op-amp circuits: Scale changer, adder, subtractor*	*LC oscillators operation: Hartley Oscillator*	*Pulse Modulation*
	SLO-2	*Clippers & Clampers*	*Operation*	*HWR & FWR*	*Colpitts Oscillator*	*Digital Transmission, Frequency Division MultiplexingTime Division Multiplexing*
S-6	SLO-1	*Basic operation of Zener diode and its VI characteristics*	*Characteristics*	*Clipper &Clamper*	*555 Timer IC: Basic Operation*	*Networks: RS-232, circuit switching*
	SLO-2	*Zener diode as a voltage regulator*	*Parameters*	*Log & Antilog amplifiers*	*Astable Operation*	*Message switching, TCP/IP*
S	SLO-1	*Lab-2: VI Characteristics of Zener Diode*	*Lab-5: Design & Analysis of CS-JFET*	*Lab-8: Op-amp Circuits-I*	*Lab-11: 555 Timer Operation &*	*Lab-14: Demonstration of Pulse*

7-8	SLO-2		*Amplifier*		*Applications*	*Modulation*
S-9	SLO-1	*BJTs: Structure & Operation*	*MOSFET as an amplifier*	*Instrumentation amplifier*	*Monostable Operation*	*Radio Transmission: Electromagnetic Spectrum, ground waves, sky waves*
	SLO-2	*Characteristics & Parameters*	*MOSFET as a switch*	*Comparator*	*Applications of 555 Timer*	*antennas, directional transmissions,*
S-10	SLO-1	*CE BJT amplifier operation*	*MOSFET Biasing (Voltage-Divider Biasing)*	*Comparator applications*	*Applications of 555 Timer*	*Transmitters, Receivers*
	SLO-2	*Differential amplifier operation*	*CS-MOSFET amplifier operation*	*Schmitt trigger*	*Voltage-Controlled Oscillators*	*Mobile telephones*
S 11-12	SLO-1 SLO-2	*Lab-3: Applications of PN Junction diode and Zener diode*	*Lab-6: Design & Analysis of CS-MOSFET Amplifier*	*Lab-9: Op-amp Circuits-II*	*Lab-12: VCO Operation*	*Mini Project / Model Practical Examination*

Learning Resources	*1. Owen Bishop, "Electronic Circuits and Systems", 4th edition, Elsevier, 2011.* *2. Harry Kybett, Earl Boysen, "All New Electronics", 3rd edition, Wiley, 2008.*	*3. Paul Scherz, "Practical Electronics for Inventors", McGraw-Hill, 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	*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 %		-	

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. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mr. Manikandan AVM, SRM IST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. Rajesh Agarwal, SRM IST*

Course Code	18ECO103T	Course Name	MODERN WIRELESS COMMUNICATION SYSTEM	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn to analyze the transmission of various wireless communication systems*
CLR-2 :	*Understand the fundamentals of various networks in wireless communication*
CLR-3 :	*Understand the techniques involved in personal communication services.*
CLR-4 :	*Introduce various wireless systems for 3G and future communication*
CLR-5 :	*Learn to analyze wireless networks for short range communication*
CLR-6 :	*Understand the Fundamentals, Techniques and Networks of Wireless Communication 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 :	*Discuss the fundamentals of transmission in wireless systems*	*2,3*	*80*	*75*	-	-	-	*H*	-	-	-	-	-	-	-	-	*H*		
CLO-2 :	*Provide an overview of various approaches to communication networks*	*2,3*	*80*	*85*	-	-	-	*H*	-	-	-	-	-	-	-	-	-	-	*H*
CLO-3 :	*Study the numerous different-generation technologies with their individual pros and cons*	*2,3*	*85*	*85*	-	-	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-4 :	*Discuss about the principles of operation of the different access technologies like FDMA, TDMA, SDMA and CDMA and their pros and cons.*	*2,3*	*85*	*80*	-	-	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-5 :	*Learn about the various mobile data services and short range networks.*	*2,3*	*85*	*80*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-6 :	*Gain knowledge on Fundamentals, Techniques and Networks of Wireless Communication Systems*	*2,3*	*85*	*80*	-	-	-	-	-	-	-	-	-	-	-	-	*H*	-	-

Duration (hour)		Transmission Fundamentals	Network Concepts	Personal Communication Services	3G and Beyond	Mobile Data Services and Short- Range Network
		9	9	9	9	9
S-1	SLO-1	*Cellphone Generations*	*Communication Networks*	*Personal communication Introduction, HSCSD, GPRS, D-AMPS, CDMA One, CDMA Two, Packet Data Systems*	*3G Introduction*	*Mobile Data Services Introduction Messaging, wireless web, WAP, site design Short-Range Wireless Networks: Unlicensed spectrum, WLANs, cordless telephony, IrDA, Bluetooth Smart Phones: Future phones, mobile OSs, smart phone applications.*
	SLO-2	*1G and 2G*	*LANs*	*GSM*	*IMT-2000 Introduction*	*Data Services*
S-2	SLO-1	*2.5G*	*MANs*	*GSM*	*IMT-2000*	*Messaging*
	SLO-2	*3G*	*WANs*	*HSCSD*	*IMT-2000*	*Wireless web*
S-3	SLO-1	*4G Transmission Introduction*	*Circuit switching*	*HSCSD*	*W-CDMA Introduction*	*WAP*
	SLO-2	*4G Transmission Fundamentals*	*Packet switching*	*GPRS*	*W-CDMA*	*Site design*
S-4	SLO-1	*Time domain concepts*	*ATM Cellular Networks Introduction*	*GPRS*	*CDMA 2000 Introduction*	*Short-Range Wireless Networks*
	SLO-2	*Frequency domain concepts*	*Cells*	*D-AMPS*	*EDGE*	*Unlicensed spectrum*
S 5-6	SLO-1	*Radio Media*	*Duplexing*	*D-AMPS*	*EDGE*	*WLANs*
	SLO-2					
S-7	SLO-1	*Analog Vs Digital*	*Multiplexing*	*CDMA Introduction*	*Wi-Fi Introduction*	*Cordless telephony*
	SLO-2	*Channel capacity*	*Voice coding*	*CDMA One*	*Wi-Fi*	*IrDA*
S-8	SLO-1	*Transmission media*	*Multiple Access Techniques: FDMA*	*CDMA One*	*WiMAX Introduction*	*Bluetooth Smart Phones*
	SLO-2	*Signaling Schemes*	*TDMA, SDMA*	*CDMA Two*	*WiMAX*	*Future phones*
S-9	SLO-1	*Carrier-based signaling,*	*CDMA*	*CDMA Two*	*OFDM*	*Mobile OSs*
	SLO-2	*Spread-spectrum signaling*	*Spectral efficiency*	*Packet Data Systems*	*MIMO*	*Smart phone applications*

Learning	*1. Simon Haykin, David Koilpillai, Michael Moher," Modern Wireless Communication", 1/e,*	*4. Andy Dornan, "The essential guide to wireless communications applications: from cellular systems to Wi-Fi",*

Resources	*Pearson Education, 2011* *2. Rappaport T.S, "Wireless Communications: Principles and Practice", 2nd edition, Pearson education.* *3. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, Aug. 2005.*	*2nd Edition, Prentice Hall, 2002.* *5. Ian F.Akyildiz, David M. Gutierrez Estevez, and Elias Chavarria Reyes, " The evolution of 4G cellular systems: LTE advanced", Physical communication, Volume 3, No. 4, pp. 217-298, Dec. 2010* *6. William Stallings, " Wireless Communication & Networking", Pearson Education Asia, 2004* *7. Andrea .F.Molisch, "Wireless communications", 2nd edition, Wiley Publications.*

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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. Sabitha Gauni, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO104J	Course Name	AUDIO AND SPEECH SIGNAL PROCESSING	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To explore about Speech signal processing*
CLR-2 :	*To explore about the human auditory system*
CLR-3 :	*Feature Extraction of Speech signal using Time characteristics*
CLR-4 :	*Frequency characteristics of Speech signal*
CLR-5 :	*Provide a foundation for developing applications in this field.*
CLR-6 :	*Understand the concept of speech processing both in time and frequency domain*

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 functioning of the human vocal and auditory systems in terms of signal processing*	*1*	*90*	*68*	*H*		*H*		*H*				-	-	-	-	*M*	*H*	
CLO-2 :	*Analyze the function of feature extraction in speech and audio signal processing using Time Domain Characteristics*	*2*	*85*	*67*	*H*			*H*				*M*	-	-	-	-	*M*		*H*
CLO-3 :	*Understand the frequency characteristics of speech signal*	*2*	*85*	*68*	*H*		*H*			*M*		*M*	-	-	-	-		*H*	*H*
CLO-4 :	*Understand the Digital models for speech signal*	*1&2*	*85*	*65*	*H*		*H*	*H*					-	-	-	-	*H*	*M*	
CLO-5 :	*Understand the elements of music*	*2&3*	*85*	*66*			*H*		*H*			*H*	-	-	-	-	*H*		*H*
CLO-6:	*Understand Speech signal processing in time and frequency domain and their models.*	*1,2,3*	*85*	*68*	*H*		*H*			*M*		*H*	-	-	-	-		*M*	*M*

		Basic Audio Processing	Human auditory system	Speech Signal Analysis in Time Domain	Speech Signal Analysis in Frequency Domain	Speech and Audio processing applications
Duration (hour)		12	12	12	12	12
S-1	SLO-1	*Introduction to Digital audio*	*Human auditory system*	*Speech signal analysis*	*Short Time Fourier analysis*	*Introduction to Speech recognition*
	SLO-2	*Capturing and converting sound*	*Human auditory system*	*Speech signal analysis*	*Short Time Fourier analysis*	*Introduction to Speech recognition*
S-2	SLO-1	*Sampling of sound wave*	*simplified model of cochlea*	*Segmental, sub-segmental levels*	*Filter bank analysis*	*Complete system for an isolated word recognition with vector quantization /DTW*
	SLO-2	*Handling audio in MATLAB*	*simplified model of cochlea*	*Suprasegmental levels*	*Formant extraction and Pitch extraction*	*Complete system for an isolated word recognition with vector quantization /DTW*
S 3-4	SLO-1	*Lab 1: Read & write a speech signal, Record a speech signal, playback, convert into a wave file, plot the speech signal, and spectrogram plot.*	*Lab 4: Short-term energy of a speech signal*	*Lab 7: Estimation of pitch period using simplified inverse filter tracking (SIFT) algorithm*	*Lab 10: Phoneme-level segmentation of speech*	*Lab 13: Compute pitch period and fundamental frequency for speech signal*
	SLO-2					
S-5	SLO-1	*Normalization*	*Sound pressure level and loudness*	*Time domain parameters of speech signal*	*Homomorphic speech analysis*	*Complete system for speaker identification, verification*
	SLO-2	*Audio processing*	*Sound pressure level and loudness*	*Time domain parameters of speech signal*	*Cepstral analysis of Speech*	*Introduction to speech enhancement*
S-6	SLO-1	*Segmentation*	*Sound intensity and Decibel sound levels*	*Methods for extracting the parameters Energy*	*Formant and Pitch Estimation*	*Introduction to speech enhancement*
	SLO-2	*Analysis of window sizing*	*Sound intensity and Decibel sound levels*	*Average ,Magnitude*	*Linear Predictive analysis of speech*	*Speech enhancement using spectral subtraction method*
S 7-8	SLO-1	*Lab 2: Convert into a wave file, plot the speech signal, and spectrogram plot*	*Lab 5: Short-time Fourier transform magnitude spectrum*	*Lab 8: Estimation of pitch period using harmonic product spectrum*	*Lab 11:To study the quantization and aliasing effect of speech signal*	*Lab 14: Short term speech analysis*
	SLO-2					
S-9	SLO-1	*Visualization*	*Concept of critical band*	*Zero crossing Rate*	*Autocorrelation method, Covariance*	*Introduction to Text to speech conversion*

					method	
	SLO-2	*Sound generation*	*Uniform filter bank , Non- uniform filter bank*	*Silence Discrimination using ZCR and energy*	*Solution of LPC equations*	*Introduction to Musical instrument classification*
S-10	SLO-1	*Speech production mechanism, Charistics of speech*	*Mel scale and bark scale,*	*Short Time Auto Correlation Function*	*Durbin's Recursive algorithm, Application of LPC parameters*	*Musical Information retrieval.*
	SLO-2	*Understanding of speech*	*Speech perception: vowel perception*	*Pitch period estimation using Auto Correlation Function*	*Pitch detection using LPC parameters, Formant analysis*	*Sample Programs*
S 11-12	SLO-1	*Lab 3:Cepstrum smoothed magnitude spectrum*	*Lab 6: (i)Linear prediction magnitude spectrum, (ii) (ii) Estimation of formant frequencies using linear prediction*	*Lab 9: Pitch and duration modification using time-domain pitch synchronous overlap and add (TD-PSOLA) method*	*Lab 12:: Speech signal to symbol transformation using wavesurfer*	*Lab 15: Study of Praat*
	SLO-2					

Learning Resources	1. *Ian McLaughlin, "Applied Speech and Audio processing, with MATLAB examples", 1st Edition, Cambridge University Press, 2009* 2. *Ben Gold, Nelson Morgan, Dan Ellis, Wiley, "Speech and Audio Signal Processing: Processing and Perception of Speech and Music", 2nd Edition, John Wiley & Sons, 01-Nov-2011.*	3. *Rabiner,B.H.Juang, "Fundamentals of Speech Recognition", 2 nd Edition, Prentice-hall Signal Processing Series, April 1993* 4. *Ken Pohlmann, "Principles of Digital Audio", 6th Edition, McGraw-Hill, 2007* 5. *A.R.Jayan, "Speech and Audio Signal Processing", ISBN : 978-81-203-5256-8, PHI Learning Pvt. Ltd, 2016.*

Learning Assessment

	Bloom'sLevel 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, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. S. Dhanalakshmi, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Mrs. K. Harisudha, SRMIST*

Course Code	18ECO105T	Course Name	UNDERWATER ACOUSTICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand what is Sound Navigation and Ranging (SONAR) and how it can be used in underwater applications.*
CLR-2 :	*Study about Ocean Acoustic Processing and sound wave propagation and analyze sea floor characteristics and ocean sounds.*
CLR-3 :	*Understand about Underwater reverberation and how types of noises affects the underwater acoustics signal data analysis.*
CLR-4 :	*Study about Acoustic transducers.*
CLR-5 :	*Know which transducers can be used for underwater applications.*
CLR-6 :	*Understand the basic theory and signal processing application for underwater communication and navigation.*

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 in-depth knowledge and analyze on Sound Navigation and Ranging (SONAR) equations and it characteristics.*	*1*	*85*	*65*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	*L*	-	-
CLO-2 :	*Analyze Ocean Acoustic Processing and sound wave propagation.*	*2*	*85*	*65*	*M*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*L*	*H*	*H*	*H*
CLO-3 :	*Acquire knowledge and analyze Underwater reverberation and various types of noises.*	*1&2*	*85*	*65*	*M*		*H*	*H*	*H*	-	-	-	-	-	-	*L*	*H*	*M*	*H*
CLO-4 :	*Acquire knowledge on working of underwater Acoustic transducers.*	*1*	*85*	*65*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*L*	*H*	*H*	*H*
CLO-5 :	*Gain knowledge and apply SONAR concepts for underwater applications.*	*1& 3*	*85*	*65*	*L*		*H*	*H*	-	-	-	-	-	-	-	*L*	*H*	*M*	*H*
CLO-6 :	*Understand the development and dynamics of underwater acoustic engineering*	*2 &3*	*85*	*65*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		Sound Navigation and Ranging (SONAR)	Ocean Acoustic Processing and sound wave propagation	Reverberation and Noises	Acoustic Transduction	SONAR Application
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to SONAR equation,*	*Processing ocean sound-Sampling rules*	*Reverberation-Scattering, back scattering strength and target strength*	*Piezoelectric transducer-Introduction*	*Echo sounder*
	SLO-2	*Source Intensity, Source Directivity*	*Spatial sampling and Temporal sampling*	*Surface and bottom scattering*	*Piezoelectric transducer-33-Mode longitudinal vibrator*	*Echo Sounder*
S-2	SLO-1	*Transmission loss*	*Filter operations-Finite Fourier transformation*	*Volume scattering, bottom scattering, reverberation target strength*	*Piezoelectric transducer-33-Mode longitudinal vibrator*	*Sub-bottom profiling*
	SLO-2	*Transmission loss*	*Filter operations-Time domain view of Band pass filtering. convolution operations, frequency domain*	*Calculation of reverberation for use in the sonar equation, Volume reverberation level*	*Electrostrictive transducers*	*Fishing sonars*
S-3	SLO-1	*Target Strength*	*Gated Signals-Dependence of Spectrum on ping carrier periodicity*	*Reverberation frequency spread and Doppler gain potential-Power spectral density of a CW pulse*	*Electrostrictive transducers*	*Side scan terrain mapping sonar*
	SLO-2	*Reflection Intensity Loss Coefficient*	*Power spectra of random signal-Signal having random characteristics, Spectral density,*	*Environmental frequency sampling*	*Magnetostrictive transducers*	*Side scan terrain mapping sonar*
S-4	SLO-1	*Sea-floor Loss,*	*Radom signal simulations-Intensity spectral density, Spectral smoothing*	*Frequency spreading due to transmitter and receiver motion*	*Magnetostrictive transducers*	*Acoustic positioning and navigation*
	SLO-2	*Sea-surface Loss*	*Matched filters and autocorrelation*	*Frequency spreading due to target, important observation with respect to reverberation*	*Electostatic Transducers*	*Acoustic positioning and navigation*

S-5	SLO-1	*Noise, Reverberation*	*Sounds in the oceans-natural physical sounds and biological sounds*	*Noise-Ambient noise models*	*Electostatic Transducers*	*3D Imaging Processing-data model*
	SLO-2	*Active and Passive Sonar Equations*	*Sound propagation in the ocean and underwater acoustic channel-Sound wave and vibration, velocity of sound*	*Ambient noise-seismic noise, ocean turbulence, shipping noise*	*Variable Reluctance Transducers*	*3D Imaging Processing-acquisition of 3D information*
S-6	SLO-1	*Passive Sonar Equations, Signal-to-Noise Ratio*	*Sound propagation in the ocean and underwater acoustic channel-Sound wave velocity of sound*	*Wave noise, thermal noise*	*Variable Reluctance Transducers*	*3D Imaging Processing-matrix approach and real time systems*
	SLO-2	*Signal Excess, Figure of Merit*	*Wave and ray theories of underwater sound fields*	*Rain noise, temporal variability of ambient noise, depth effects of noise*	*Moving coil transducers*	*3D Imaging Processing-Image representation, Acoustic image processing*
S-7	SLO-1	*Active SONAR target strength*	*Wave and ray theories of underwater sound fields*	*Under ice noise*	*Moving coil transducers*	*3D Imaging Processing-Segmentation and reconstruction of underwater tubular structures*
	SLO-2	*Active SONAR- reverberation, detection threshold*	*Wave and ray theories of underwater sound fields*	*Spatial coherence of ambient noise*	*Equivalent circuits-Basics Circuit Resonance*	*3D Imaging Processing-Segmentation and reconstruction of underwater tubular structures*
S-8	SLO-1	*Active Sonar Sources- Source Level, Cavitation*	*Sound absorption in sea water and its characteristics*	*Self-noise-Flow noise*	*Circuit Q and Bandwidth*	*Acoustic communication-Cross attributes of the received signal*
	SLO-2	*Near-Field Interactions Explosive Sources*	*Upper boundary of acoustic channel*	*Self-noise – Flow noise*	*Transducers as projectors-principle*	*Acoustic communication-channel transfer function*
S-9	SLO-1	*Physics of Shock Waves in Wate, Bubble Pulses*	*Lower boundary of acoustic channel and its characteristics*	*Self noise-turbulent noise coherence*	*Transducers as Hydrophones-principles of operations*	*Acoustic communication-combating multipath*
	SLO-2	*Pros and Cons of Explosive Charges, Parametric Acoustic Sources*	*sound field in shallow water*	*Self noise-strumming noise*	*Transducers as Hydrophones-simplified equivalent circuit*	*Acoustic communication-diversity reception, equalization*

Learning Resources	1. *Richard P HODGES, "Underwater Acoustics – Analysis, Design and Performance of SONAR", Wiley 1 edition2010, ISBN 978-0-470-68875-* 2. *Rodney F W Coates, "Underwater Acoustics Systems", Macmillan New Electronics,Wiley, 1st edition , 1990, ISBN 978-0-333-42542-8* 3. *Robert S H Istepanian and MilicaStojanovic, "Underwater Acoustic Digital Signal Processing and Communication Systems", Springer, 2002 edition, ISBN 978-1-4419-4882-3*	4. *Charles H Sherman, John L Butler, "Transducers and Arrays for Underwater Sound", Springer; 2nd edition, 2016, ISBN-10: 0-387-32940-4 ISBN-13: 978-0387-32940-6* 5. *Qihu Li, "Digital Sonar Design in underwater acoustics: Principles and applications", Springer, Zhejang University Press, 2012* 6. *Herman Medwin, Clarence S.Clay, "Fundamentals of Acoustical Oceanography", Academic Press, 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, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. S. Dhanalakshmi, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO107T	Course Name	FIBER OPTICS AND OPTOELECTRONICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Analyze the basic laws and theorems of light associated with the optical fiber communication and the classification of optical fibers*
CLR-2 :	*Address concepts related to transmission characteristics such as attenuation and dispersion.*
CLR-3 :	*Explore the fundamentals of optoelectronics display devices, Sources and Detectors*
CLR-4 :	*Gain to information on Optical modulators and amplifiers*
CLR-5 :	*Illustrate the integration methods available for optoelectronic circuits and devices*
CLR-6 :	*Utilize the basic optical concepts applied in various engineering problems and identify appropriate solutions*

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 :	*Review the basic theorems related to fiber optic communication, and attain knowledge of types of optical fibers*	*2*	*80*	*70*
CLO-2 :	*Understand the optical signal distortion factors in optical fiber communication*	*2*	*85*	*75*
CLO-3 :	*Familiarize the principle and operation of various display devices, light sources and detectors*	*2*	*75*	*70*
CLO-4 :	*Acquire knowledge of various optoelectronic modulators and amplifiers*	*2*	*85*	*80*
CLO-5 :	*Understand the various optoelectronic integrated circuits*	*2*	*85*	*75*
CLO-6:	*Acquire fundamental concepts related to optical communication and optoelectronic devices*	*2*	*80*	*75*

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*	-	-	-	-	-	-	-	-	-	-	-	*M*
H	*M*	*M*	-	-	-	-	-	-	-	-	-	-	-	*L*
H	-	*M*	-	-	-	-	-	-	-	-	-	-	-	*H*
H	-	*M*	*L*	-	-	-	-	-	-	-	-	-	-	*L*
H	*M*	*M*	*L*	-	-	-	-	-	-	-	-	-	-	*H*

Duration (hour)		Introduction to Optical Fibers	Transmission Characteristics of Optical Fibers	Display Devices, Light Sources and Detection Devices	Optoelectronic Modulators and Switching Devices	Optoelectronic Integrated Circuits
		9	9	9	9	9
S-1	SLO-1	*Evolution of fiber optic system*	*Attenuation – Absorption, Attenuation units*	*Display devices – Photo luminescence*	*Analog and Digital Modulation*	*Optoelectronic integrated circuits - Introduction*
	SLO-2	*Elements of an optical fiber transmission link*	*Attenuation – Scattering losses*	*Cathode luminescence*	*Electro optic modulators – Electro optic effect – Longitudinal electro optic modulator*	*Need for Integration - Hybrid and Monolithic Integration*
S-2	SLO-1	*Elements of an optical fiber transmission link*	*Attenuation – Bending losses, microbending and macro bending losses*	*Electro luminescence*	*Electro optic modulators – Transverse electro optic modulator*	*Hybrid and Monolithic Integration*
	SLO-2	*Advantages of fiber optic system*	*Attenuation - Core cladding losses*	*Injection luminescence*	*Acousto optic modulators – Transmission type – Raman Nath modulator*	*Materials and processing of OEICs*
S-3	SLO-1	*Characteristics and behavior of light*	*Signal distortion in optical waveguides*	*Light source materials*	*Acousto optic modulators – Reflection type – Bragg modulator*	*Application of optoelectronic integrated circuits*
	SLO-2	*Total internal reflection*	*Types of dispersion-Intramodal and Intermodal dispersion*	*Surface emitting LEDs*	*Solving Problems*	*Slab and Strip Waveguides*
S-4	SLO-1	*Acceptance angle*	*Material dispersion*	*Edge emitting LEDs*	*Optical switching and logic devices – self-electro-optic-device*	*Integrated transmitters and receivers – Front end photo receivers*
	SLO-2	*Numerical aperture, Critical angle*	*Material dispersion, Waveguide dispersion*	*Quantum efficiency and LED power – Internal quantum efficiency derivation*	*Optical switching and logic devices – Bipolar controller modulator*	*Integrated transmitters and receivers – photoreceiver noise and bandwidth considerations*
S-5	SLO-1	*Solving Problems*	*Waveguide dispersion*	*Quantum efficiency and LED power – External quantum efficiency and total LED power*	*Optical switching and logic devices-tunable threshold logic gate – Switching speed and energy.*	*Integrated transmitters and receivers – PIN-HBT photoreceivers*
	SLO-2	*Solving Problems*	*Signal distortion in single mode fibers*	*Solving Problems*	*Optical Amplifiers – General applications of*	*Integrated transmitters and receivers –*

					optical amplifiers	*OEIC transmitters – equivalent circuit for integrated receivers*
S-6	SLO-1	*Ray optics*	*Polarization mode dispersion*	*Semiconductor laser diode*	*Semiconductor optical amplifiers – Basic configuration*	*Integrated transmitters and receivers – Complex circuits and arrays*
	SLO-2	*Types of rays*	*Polarization mode dispersion, Intermodal dispersion*	*Modes and threshold condition*	*Semiconductor optical amplifiers – Optical gain - Limitations*	*Integrated transmitters and receivers - optical control and microwave oscillators*
S-7	SLO-1	*Optical fiber modes*	*Intermodal dispersion*	*Photo detection principle*	*Erbium doped fiber amplifiers – energy level diagram and amplification mechanism*	*Guided wave devices – Waveguide and couplers*
	SLO-2	*Optical fiber configurations*	*Solving Problems*	*PIN Photodiode*	*Erbium doped fiber amplifiers – EDFA configuration*	*Guided wave devices – Active guided wave devices*
S-8	SLO-1	*Single mode fibers*	*Solving Problems*	*PIN photodiode - Avalanche Photodiode*	*Solving Problems*	*Guided wave devices – Mach Zehnder Interferometers*
	SLO-2	*Multimode Fibers*	*Pulse Broadening in Graded Index Waveguides*	*Avalanche Photodiode*	*Solving Problems*	*Active couplers*
S-9	SLO-1	*Step Index Fibers*	*Mode Coupling*	*Noise mechanism in photodetectors*	*Fiber Raman Amplifiers – Configuration – Forward pumping*	*Active Couplers*
	SLO-2	*Graded Index Fibers*	*Design Optimization of Single Mode Fibers*	*Solving Problems*	*Fiber Raman Amplifiers – Backward pumping*	*Active Couplers*

Learning Resources	*1. Gerd Keiser, "Optical Fiber Communications", 5th Edition, McGraw Hill Education (India), 2015.* *2. Khare R P, "Fiber Optics and Optoelectronics", Oxford University Press, 2014.*	*3. J. Wilson and J. Hawkes, "Optoelectronics – An Introduction", Prentice Hall, 1995.* *4. Pallab Bhattacharya, "Semiconductor Optoelectronic Devices", Prentice Hall of India Pvt. Ltd, 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
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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO109J	Course Name	EMBEDDED SYSTEM DESIGN USING RASPBERRY PI	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understanding the programing of python for Raspberry Pi*
CLR-2 :	*Applying python programming on GPIO and interfacing motors using Raspberry Pi*
CLR-3 :	*Applying python programming on GPIO switch and keyboard*
CLR-4 :	*Create insights to the concepts and programming of motion detection ,GPS programming, light sensor ,gas detection*
CLR-5 :	*Analyze and understand the working principle and data sheet of temperature sensor, gas sensor ,ADC, ultrasonic rangefinder, Acceleration and light sensor*
CLR-6 :	*Utilize the technology of node js ,cloud service and MQTT Protocol for moving sensor data to web*

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 python for Raspberry Pi*	*2*	*80*	*70*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	*H*	-	-
CLO-2 :	*Analyze data sheet and functioning of sensors*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	-	*H*
CLO-3 :	*Apply python programming on GPIO of Raspberry Pi and interfacing of sensor*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	-	-
CLO-4 :	*Apply python programming on GPIO of Raspberry Pi to interfacing of actuators*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*H*	-	-
CLO-5 :	*Apply python programming on GPIO of Raspberry Pi to interfacing input and display device*	*2*	*85*	*75*	*H*	-	*H*	*H*	-	-	-	-	-	-	-	-	*H*	-	-
CLO-6 :	*Apply technology of node js ,cloud service and MQTT Protocol for IOT application*	*2*	*80*	*70*	*H*	-	*H*	-	*H*	-	-	-	-	-	-	-	-	-	*H*

Duration (hour)		Basic python programming	Programming interrupts –Motor control, switches and keyboard interface	Sensor interface and programming	Temperature sensor and display interface programming	Publishing sensor data on web service
		12	12	12	12	12
S-1	SLO-1	*Python Basics- Editing Python Programs with IDLE, Variables, displaying Output, Reading User Input , Arithmetic, Creating Strings*	*Programming with Interrupts*	*Detecting Movement-PIR sensor*	*Measuring Temperature Using a Digital Sensor*	*publish sensor data on web service-building a home security dash board*
	SLO-2	*Concatenating (Joining) Strings, Converting Numbers to Strings, Converting Strings to Numbers ,Find the Length of a String, Find the Position of One String Inside Another, Extracting Part of a String, Replacing One String of Characters with Another Inside a String ,Converting a String to Upper- or Lowercase*	*Programming with Interrupts*	*Data sheet analysis of PIR sensor*	*Data sheet analysis Digital Temperature Sensor*	*publish sensor data on web service-building a home security dash board*
S-2	SLO-1	*Running Commands Conditionally, Comparing Values, Logical Operators,*	*Controlling GPIO Outputs Using a Web Interface*	*Adding GPS to the Raspberry Pi*	*Measuring Distance-ultrasonic rangefinder*	*MQTT Protocol*
	SLO-2	*Repeating Instructions an Exact Number of Times ,Repeating Instructions Until Some Condition Changes , Breaking Out of a Loop, Defining a Function in Python*	*Controlling GPIO Outputs Using a Web Interface*	*Data sheet analysis of GPS*	*Data sheet analysis ultrasonic rangefinder*	*MQTT Protocol- installation and setting account ,token creation ,reading sensor data and pushing to thingsboard*
S-3-4	SLO-1	*Lab 1: Arithmetic and string*	*Lab 7: Programming on interrupts*	*Lab 13: Programming on PIR sensor*	*Lab 19: Programming on Digital Temperature Sensor*	*Lab 25: Publish sensor data on web service*
	SLO-2	*Lab 2: Loop*	*Lab 8: Programming on Web Interface*	*Lab 14: Programming on GPS*	*Lab 20: Programming on ultrasonic rangefinder*	*Lab 26: Publish sensor data on web service*

S-5	SLO-1	*Creating a List , Accessing Elements of a List, Find the Length of a List , Adding Elements to a List , Removing Elements from a List,*	*Controlling Servo Motors using PWM*	*Using Resistive Sensors*	*Logging to a USB Flash Drive*	*basic of java scripts –node.js*
	SLO-2	*Creating a List by Parsing a String, Iterating over a List, Enumerating a List, Sorting a List, Cutting Up a List. Applying a Function to a List*	*Controlling the Speed of a DC Motor*	*Measuring Light*	*Logging to a USB Flash Drive*	*Modules-HTML module*
S-6	SLO-1	*Creating a Dictionary ,Accessing a Dictionary, Removing Things from a Dictionary,*	*Controlling the Direction of a DC Motor*	*Detecting Methane*	*Using a Four-Digit LED Display*	*Modules –file –event*
	SLO-2	*Iterating over Dictionaries*	*Using a Unipolar Stepper Motor*	*Data sheet analysis of gas sensor*	*Displaying Messages on an I2C LED matrix with data sheet discussion*	*Modules –file –event*
S 7-8	SLO-1	*Lab 3: Program on list*	*Lab 9: Programming on Stepper Motor*	*Lab 15: Programming on light sensor*	*Lab 21: Programming on Four-Digit LED Display*	*Lab 27: Programming on node js HTML module*
	SLO-2	*Lab 4: Program on Dictionary*	*Lab 10: Programming on DC Motor*	*Lab 16: Programming on Gas sensor*	*Lab 22: Programming on I2C LED matrix*	*Lab 28: Programming on node js file and event module*
S-9	SLO-1	*Controlling Hardware-Connecting an LED-Controlling the Brightness of an LED*	*Using a Bipolar Stepper Motor*	*Measuring a Voltage using MCP3008 And data sheet of MCP3008*	*Displaying Messages on an Alphanumeric LCD*	*LED blinking using node.js*
	SLO-2	*a Buzzing Sound*	*Building a Simple Robot Rover*	*Using Resistive Sensors with an ADC*	*Displaying Messages on an Alphanumeric LCD*	*LED blinking using node.js*
S-10	SLO-1	*Switching a High-Power DC Device Using a Transistor*	*Digital Inputs-Connecting a Push Switch-Toggling with a Push Switch-Using a Two-Position Toggle or Slide Switch*	*Measuring Temperature with an ADC*	*Cloud service for IOT*	*building java script client using MQTT broker*
	SLO-2	*Switching a High-Power Device Using a Relay*	*Using a Rotary (Quadrature) Encoder and Using a Keypad*	*Measuring Acceleration and data sheet discussion of Acceleration sensor*	*Cloud service for IOT*	*building java script client using MQTT broker*
S 11,12	SLO-1	*Lab 5: LED blinking and Brightness control*	*Lab 11: Programming on Switch*	*Lab 17: Programming on ADC*	*Lab 23: Programming on an Alphanumeric LCD*	*Lab 29: Programming on LED blinking using node.js*
	SLO-2	*Lab 6: Switching a High-Power DC Device*	*Lab 12: Programming on Keypad*	*Lab 18: Programming on Measuring Acceleration*	*Lab 24: Programming on an Alphanumeric LCD*	*Lab 30: Building java script client using MQTT broker*

Learning Resources	1. *Simon Monk, "Raspberry Pi Cookbook", O'Reilly Media, Inc, 2014.* 2. *Volker Ziemann, "A Hands-On Course in Sensors Using the Arduino and Raspberry Pi, CRC Press, 2018.* 3. *https://thingsboard.io/docs/*	4. *Colin Dow, "Internet of Thing: Programming Projects - Build modern IoT solutions with the Raspberry Pi 3 and Python", packtpub 2018.* 5. *https://www.w3schools.com/nodejs/nodejs_raspberrypi_blinking_led.asp*

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, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. P. Vijayakumar, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO110J	Course Name	3D PRINTING HARDWARE AND SOFTWARE	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	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the tools available for 3D printing*
CLR-2 :	*Familiarize with 3D design software and hardware*
CLR-3 :	*Understand the 3D design criteria and its limitations.*
CLR-4 :	*Learn the contemporary technology available for 3D design and printing*
CLR-5 :	*Understand various post processing methods involved in 3D printing technology*
CLR-6 :	*Develop the skillset on 3D component design and development using contemporary commercial software and hardware available.*

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 3D printing tools for components design*	*1*	*80*	*60*	*M*				*M*										
CLO-2 :	*Able to optimistically select the 3D design software and hardware for the given problem*	*1*	*80*	*60*	*M*				*H*										
CLO-3 :	*Capability to solve 3D design components design problems*	*2*	*75*	*60*	*M*			*M*										*M*	
CLO-4 :	*Choose the contemporary technology available for 3D design and printing*	*3*	*80*	*60*			*M*											*M*	*L*
CLO-5 :	*Apply various post processing methods involved in 3D printing technology*	*2*	*80*	*60*		*H*													
CLO-6 :	*Ability to develop the skillset on 3D component design and development using contemporary commercial software and hardware available.*	*2*	*80*	*60*											*M*			*M*	

Duration (hour)		Introductions to 3D design tools	Three-dimensional (3D) Modeling	3D Design Fundamentals and Projects	3D Printing and its Technologies	Post Processing - Product Visualization and Print Cleaning
		12	12	12	12	12
S-1	SLO-1	*Introduction to Maya GUI - Object creation workflow, Constructing object primitives to scale and with accuracy*	*An overview of CAD software packages - Introduction to Fusion 360 - Drawing based workflow, Drawing constraints - Surfacing operations.*	*The good, the bad, and the ugly of design*	*History of 3D printing - Overview of 3D Printing technologies*	*Workflows for printing*
	SLO-2					
S-2	SLO-1	*Duplication and arrayed duplication - Grid and point/vertex snapping*	*Moving Parts and Articulation Hinges - Ball and sockets*	*Prominent Designers*	*Selective Laser Sintering (SLS) Direct Metal Laser Sintering (DMLS)*	*Software and Drivers - Formats for Printing (SLA, OBJ, CAD, etc.)*
	SLO-2					
S 3-4	SLO-1	*Understanding NURBS: NURBS Surfaces advantages, Similarities and differences between NURBS and CAD drawings Curve and surface construction*	*Creating a part negative, Creating Text in Maya the proper way (NURBS Curves, surface lofts, conversion to polygon) Painterly tools (Sculpt Geometry Tool, etc.)*	*Franchises Success stories, Pop culture*	*Vacuum forming - Resin casting - Injection Molding - Terms and standards for injection molding systems*	*Post and Export Print Lab setup*
	SLO-2					
S-5	SLO-1	*Understanding 3D geometry - Modeling workflows for Polygons - Additive vs. Subtractive Tools - Mesh editing*	*Flexibility and elasticity, Locks, bolts, and fasteners Threading (taps and dies)*	*Early decision making criteria*	*Fused Deposition Modeling (FDM) - Stereolithography (SLA)*	*Cleanup and airtight modeling*
	SLO-2					
S-6	SLO-1	*Best Practices for constructing printable polygon meshes*	*Interfacing, support, and reinforcement*	*Knowing the product*	*Laminated Object Manufacturing (LOM) - Electron Beam Melting (EBM)*	*Loading models and arranging print stage*
	SLO-2	*Fundamental Structure - Combining, merging, and sewing up polygon meshes*				

S 7-8	SLO-1	*Best Practices for constructing printable polygon meshes - Fundamental Structure - Combining, merging, and sewing up polygon meshes*	*How the modeling software packages differ from CAD packages, Sketch/drawing based workflows, Similarities and differences between CAD and NURBS.*	*Brainstorming and critique in the early design phase Group critiques of in-progress projects*	*Printing Resolutions and Tolerances Materials Properties (Temperature, Flexibility, Strength, Brittleness)*	*Printing - Removing support material*
	SLO-2					
S-9	SLO-1	*Understanding two-manifold vs. non-manifold geometry*	*Form and function visualizing the assembly process*	*Early decision-making criteria Knowing the product Vision and Reality*	*3D Printing (3DP) – Selective laser melting (SLM)*	*Special topics – 3D Scanners and its types*
	SLO-2	*Exporting geometry - Laying out a simple model on a stage for print*				
S-10	SLO-1	*Hollow forms and the importance of reducing volume Cost of size, cost of volume, cost of detail, cost of time State table*	*Complex interactions and motorizations*	*Calculating the total cost Progress checks and group critiques of in-progress projects*	*Final cleanup and processing of files for printing*	*Reverse engineering, Concepts and its hardware and software*
	SLO-2					
S 11-12	SLO-1	*Clean and uniform topology, Illustrator, IGES, and other import/export pipelines*	*Broad overview of manufacturing techniques Molding, sculpting, lathing, lofting, welding, cutting, drilling, gluing, etc*	*Brainstorming and critique in the early design phase Group critiques of in-progress projects*	*Planning for injection molding - 3D Printing for injection molding*	*High speed machining*
	SLO-2					

Learning Resources	1. *Hod Lipson, Melba Kurman, Fabricated: The New World of 3D Printing, Wiley, 2013* 2. *Matthew Griffin, Design and Modeling for 3D Printing, Maker Media, Inc., 2013.* 3. *Rob Thompson, Manufacturing Processes for Design Professionals, Thames & Hudson; Reprint edition, 2007.* 4. *https://web.stanford.edu/class/me137/* 5. *SolidWorks Gallery: http://www.3dcontentcentral.com/default.aspx*	6. *3D Anatomy Models: http://lifesciencedb.jp/bp3d/?lng=en* 7. *AutoDesk Fusion360 HomePage: http://fusion360.autodesk.com* 8. *International Journal of Rapid Manufacturing* 9. *Academic Journals on 3D Printing* 10. *International Journal of Rapid Manufacturing*

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, Conf. Paper etc.,

Course Designers		
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1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mr. S. Karuppudaiyan, Mechanical, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. P. Eswaran, SRMIST*

Course Code	18ECO126T	Course Name	SPORTS BIOMECHANICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE267J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamental muscle action and locomotion in biomechanical point of view*
CLR-2 :	*Get an idea about the movement patterns and causes of movements*
CLR-3 :	*Understand the qualitative and quantitative analysis of sports movements*
CLR-4 :	*Acquire an idea about the basic concept of jumping & aerial movement and throwing & hitting*
CLR-5 :	*Get an idea about the injury prevention, rehabilitation and special Olympic sports*
CLR-6 :	*Get an overall idea about the applications of biomechanics in sports*

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 :	*Illustrate the muscle action in sport and locomotion*	*1*	*80*	*70*	*M*												*L*		
CLO-2 :	*Analyze the movement patterns and its causes*	*1,2*	*80*	*70*	*M*												*M*		
CLO-3 :	*Describe the Qualitative and Quantitative analysis of sports movements*	*2*	*80*	*70*	*M*												*M*		
CLO-4 :	*Analyze the movement of action such as jumping, throwing, hitting and aerial movement*	*2*	*80*	*70*			*L*										*L*	*L*	*L*
CLO-5 :	*Identify the injury scenario and special Olympic sports*	*2*	*80*	*70*													*L*	*L*	*L*
CLO-6 :	*Outline the major concepts in sports biomechanics*																		

Duration (hour)		Muscle Action in Sport and Exercise and locomotion- Biomechanical view	Movement patterns and its causes	Qualitative and Quantitative analysis of sports movements	Jumping and Aerial Movement, Throwing and Hitting	Injury Prevention, Rehabilitation and Special Olympic Sports
		9	9	9	9	9
S-1	SLO-1	*Introduction to Biomechanics*	*Introduction to Movement patterns*	*Introduction to Analysis of Sport Movements*	*Introduction to Aerial movement*	*Mechanisms of Musculoskeletal Injury*
	SLO-2	*Applications of Biomechanics*	*Defining human movements*	*A structured analysis framework*	*Types of Aerial Movement - Rotation during flight, Motion of the mass centre*	*Musculoskeletal Loading During Landing*
S-2	SLO-1	*Neural Contributions to Changes in Muscle Strength*	*Fundamental movements-Walking, Running*	*Preparation stage*	*Types of Aerial Movement : Somersaulting, Twisting,*	*Sport-Related Spinal Injuries and their Prevention*
	SLO-2	*Mechanical Properties and Performance in Skeletal Muscles*	*Fundamental movements-Throwing, Jumping*	*Observation stage*	*Control of aerial movement*	*Sport-Related Spinal Injuries and their Prevention*
S-3	SLO-1	*Muscle-Tendon Architecture*	*qualitative and quantitative movement*	*Evaluation and diagnosis stage*	*Introduction : High Jump*	*Impact Propagation and its Effects on the Human Body*
	SLO-2	*Athletic Performance*	*Comparison of qualitative and quantitative movement analysis*	*Intervention stage – providing appropriate feedback*	*Techniques of Jumping - Skating, Springboard and Platform Diving*	*Impact Propagation and its Effects on the Human Body*
S-4	SLO-1	*Eccentric Muscle Action in Sport and Exercise*	*Movement patterns-geometry of motion*	*Identifying critical features of a movement*	*Determinants of Successful Ski-Jumping Performance*	*Neuromechanics of the Initial Phase of Eccentric Contraction*
	SLO-2	*Stretch–Shortening Cycle of Muscle Function*	*Fundamentals of movement*	*Identifying critical features of a movement*	*Determinants of Successful Ski-Jumping Performance*	*Induced Muscle Injury*
S-5	SLO-1	*Biomechanical Foundations of Strength*	*Linear motion and the centre of mass*	*The use of videography in recording sports movements*	*Principles of Throwing*	*Manual Wheelchair Propulsion*
	SLO-2	*Power Training*	*The geometry of angular motion and the coordination of joint rotations*	*The use of videography in recording sports movements*	*The Flight of Sports Projectiles*	

S-6	SLO-1	*Factors Affecting Preferred Rates of Movement in Cyclic Activities*	*Forces in sport*	*Recording the movement*	*Javelin Throwing: an Approach to Performance Development*	*Sports after Amputation*
	SLO-2	*The Dynamics of Running*	*Combinations of forces on the sports performer*	*Experimental procedures -Two dimensional videography*		
S-7	SLO-1	*Resistive Forces in Swimming*	*Momentum and the laws of linear motion*	*Experimental procedures -Three dimensional videography*	*Shot Putting*	*Biomechanics of Dance*
	SLO-2	*Propulsive Forces in Swimming*	*Force–time graphs as movement patterns*	*Data processing*	*Hammer Throwing: Problems and Prospects*	
S-8	SLO-1	*Performance-Determining Factors in Speed Skating*	*Determination of the centre of mass of the human body*	*Projectile motion*	*Hammer Throwing: Problems and Prospects*	*Biomechanics of Martial arts*
	SLO-2	*Cross-Country Skiing: Technique*	*Fundamentals of angular kinetics and Generation and control of angular momentum*	*Linear velocities and accelerations caused by rotation*	*Hitting*	
S-9	SLO-1	*Cross-Country Skiing: Equipment*	*Measurement of force*	*Rotation in three-dimensional space*	*Kicking*	*Biomechancis of YOGA*
	SLO-2	*Factors Affecting Performance*	*Measurement of pressure*	*Rotation in three-dimensional space*	*Simple concept problems*	

Learning Resources	1. *Susan J Hall, "Basic Biomechanics", McGraw-Hill Higher Education, 7th edition, 2014* 2. *Vladimir M. Zatsiorsky, Biomechanics in Sports: Performance Enhancement and Injury Prevention, 1st ed., Blackwell Science Ltd, 2000*	3. *Jules Mitchell,"Yoga Biomechanics", 1* edition *, Handspring Publishing Limited ,2018* 4. *Roger Bartlett, Introduction to Sports Biomechanics: Analysing Human Movement Patterns, 2nd ed., Routledge, 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 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*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. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu*	*1. Ms. Oinam Robita Chanu, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr .D. Ashok kumar, SRMIST*
3 Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO135T	Course Name	FUNDAMENTALS OF MEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the importance of micro system technology*
CLR-2 :	*Learn the operating principle of various micro sensors and actuators*
CLR-3 :	*Impart the applications of various micro fabrication techniques*
CLR-4 :	*Understand the differences and need for microfabrication*
CLR-5 :	*Operate MEMS design tools to design simple micro devices*
CLR-6 :	*Understand recent developments and challenges in MEMS*

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 :	*Appreciate the fundamental concepts in MEMS technology*	*2,3*	*80*	*80*	*H*	-	-	-	-	*H*	-	-	-	-	-	*H*	*H*	-	*H*	
CLO-2 :	*Understand the fabrication and machining techniques of MEMS devices*	*1,2*	*80*	*80*	*H*	-	-	-	-	*H*	-	-	-	-	-	*H*	-	-	*H*	
CLO-3 :	*Familiarize with the concepts of packaging of MEMS devices*	*1*	*80*	*80*	*H*	-	-	*H*	-	*H*	-	-	-	-	-	*H*	*H*	-	*H*	
CLO-4 :	*Appreciate the significance of micro fabrication processes*	*3*	*80*	*80*	*H*	-	-	*H*	-	-	-	-	-	-	-	*H*	-	-	*H*	
CLO-5 :	*Design and Simulate simple structures using MEMS software*	*3*	*80*	*80*	*H*	-	*H*	*H*	*H*	-	-	*H*	*H*	-	-	*H*	*H*	-	*H*	
CLO-6 :	*Analyze recent trends and developments in MEMS technology*	*3*	*80*	*80*	*H*	-	-	*H*	-	-	-	-	-	-	-	*H*	*H*	-	*H*	

		Introduction	Fabrication overview	Micromachining	Bonding & Sealing	Recent trends
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to MEMS and Brief recap of Macro devices*	*Introduction to Micro fabrication process*	*Introduction of micro machining(MMC) process*	*Introduction to MEMS packaging*	*Introduction to design tools and simulation*
	SLO-2	*Microelectronics and Micro systems*	*Significance of each technique*	*Significance of MMC*	*Challenges in packaging*	*FEM analysis*
S-2	SLO-1	*Scaling laws in geometry*	*Process Description of Photolithography*	*Bulk MMC process – merits and demerits*	*Different levels of Packaging*	*Design of a silicon die for a micro pressure sensor*
	SLO-2	*Silicon as ideal material and as substrate*	*Implementation of Photolithography*	*Sequence of steps*	*Die, device and system level*	*Simulation in software*
S-3	SLO-1	*Si wafer production*	*Process Description of CVD*	*Significance of Isotropic etching*	*Differences in IC packaging technology and MEMS packaging*	*Application of MEMS in automotive industry*
	SLO-2	*Cz process*	*Implementation, merits and demerits of CVD*	*Anisotropic etching*		*Airbag deployment*
S-4	SLO-1	*Sequential steps in wafer processing*	*Process Description of PVD*	*Surface MMC process*	*Die Preparation*	*Optical MEMS Application*
	SLO-2		*Implementation, merits and demerits of PVD*	*Sequence of steps*	*Plastic encapsulation and its significance*	*Micro mirrors*
S-5	SLO-1	*Chemical and mechanical properties of Si and compounds*	*Process Description, implementation of Ion implantation*	*Challenges in surface MMC*	*Types of wire bonding Thermo compression type*	*Micro fluidics Application*
	SLO-2	*Chemical and mechanical properties of Polymers, Quartz and GaAs*	*Oxidation process*	*Interfacial & Residual stresses*	*Thermo sonic, Ultra sonic type*	*Lab on chip module*
S-6	SLO-1	*Chemical, Biomedical type Micro sensors*	*Diffusion process*	*LIGA process- description merits and demerits*	*Types of surface bonding – Adhesive*	*IR and Gas sensing*
	SLO-2	*Piezoelectric type of Micro sensors*	*Wet etching methods*	*Implementation*	*soldering, SOI type of bonding*	*Thermal sensors*
S-7	SLO-1	*Thermal, SMA, Piezoelectric actuators*	*Properties of etchants*	*Process Design-block diagram and description*	*Anodic bonding and lift off process*	*Micro power generation*

	SLO-2	*Electro static type Micro Actuators*	*Dry etching methods*	*Electro-mechanical design, Thermo-electric design*	*Precautions to be taken*	*Micro TEG*
S-8	SLO-1	*Micro devices- operation of Micro gears and micromotors*	*Production of plasma*	*CAD- block diagram description and implementation*	*Types of sealing- Micro shells, Hermetic sealing*	*Chemical sensors*
	SLO-2	*Micro devices –operation of Micro valves and pumps*	*Etch stop methods*		*Micro 'O' rings,Reactive seal*	*Micro humidity sensors*
S-9	SLO-1	*Case study*	*Case study*	*Case study*	*Selection of packaging materials*	*Micro pressure sensors*
	SLO-2				*Material requirements*	*Paper MEMS*

Learning Resources	*1. Tai-Ran Hsu, "MEMS and MICROSYSTEMS", 22nd reprint edition, Wiley & sons, 2015* *2. M. Madou, "Fundamentals of Micro fabrication", Taylor and Francis group, 2002*	*3. VardhanGardener,"Micro sensors and smart devices", John Wiley & Sons,2001* *4. NPTEL link: https://nptel.ac.in/downloads/112108092/*

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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr. A. Vimala Juliet, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. R.Bakiyalakshmi,SRMIST*

Course Code	18MEO101T	Course Name	ROBOTICS ENGINEERING AND APPLICATIONS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with basic concepts of robotics*
CLR-2 :	*Be familiar with various end effectors and transformation techniques*
CLR-3 :	*Be familiar with different sensors and system controllers*
CLR-4 :	*Be familiar with the design of robot work cell layouts and interfacing*
CLR-5 :	*Be familiar with different robot programming languages and applications in different fields*

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 basic concepts of robotics*	*1& 2*	*90*	*85*	*H*		*M*												
CLO-2 :	*Understand the various end effectors and application of transformation techniques*	*1*	*90*	*85*	*H*		*M*		*M*		*M*								
CLO-3 :	*Understand the different sensors and system controllers*	*1*	*90*	*85*	*H*						*M*								
CLO-4 :	*Understand the design of robot work cell layouts and interfacing*	*1&2*	*90*	*85*	*H*								*H*						
CLO-5 :	*Understand the different robot programming languages and applications in different fields*	*1&2*	*90*	*85*	*H*														

		Basic concepts of robotics	End effectors and transformation techniques	Sensors and system controllers	Work cell design layouts and interfacing	Robot programming languages and applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts of robotics (Laws of robotics, robotic systems), RIA definition*	*End effectors-Introduction, classification.*	*Sensor devices*	*Robot cell lay outs*	*Robot language, classification.*
S-2	SLO-1	*Robot anatomy (Robot configurations, Robot motions, Joint notation scheme) , Manipulators*	*Mechanical, Magnetic grippers.*	*Types of sensors (contact, position and displacement sensors)*	*Robot work cell design and control*	*Programming methods, off and on line programming.*
S-3	SLO-1	*Precision movement (Spatial resolution, accuracy, repeatability) Work volume, robot specifications*	*Vacuum and adhesive gripper*	*Force and torque sensors*	*Multiple robots*	*Lead through method, powered and Manual lead through and Teach pendent method.*
S-4	SLO-1	*Types of Robot drives - electric drives*	*Gripper design and Gripper force analysis*	*Proximity and range sensors, acoustic sensors.*	*Machine interface*	*VAL systems and language, Simple program.*
S-5	SLO-1	*Hydraulic and pneumatic drives*	*Orientation of wrist*	*Robot vision systems, Sensing and digitizing.*	*Safety considerations in cell design*	*Application of Robots, Material handling, Constrains, Machine loading and unloading.*
S-6	SLO-1	*Basic robot motions, Point to point control and continuous path control.*	*2D transformation (scaling, rotation, translation)*	*Image processing and analysis.*	*Interlocks in work cell*	*Assembly Robot, Assembly operation, RCC device, Benefits- Inspection robot, used in Quality control.*
S-7	SLO-1	*Forward and inverse kinematics for 2DOF manipulator*	*3D transformation (scaling, rotation, translation)*	*Robot control system - Unit control system*	*Types of work cell controllers*	*Welding and Spray painting Robots, features, sensors, Advantages*
S-8	SLO-1	*Forward and inverse kinematics for 3DOF manipulator*	*Homogeneous transformations*	*Adaptive and Optimal control*	*Robot cycle time analysis*	*Mobile and microbots, types, mobility and application.*
S-9	SLO-1	*Machine intelligence*	*Coordinate frames - Description of Objects in Space*	*Basic Relationship Between Pixels*	*Error detection and Error recovery*	*Search techniques in AI and robotics*

Learning Resources	1. *Mikell P. Groover, "Industrial Robotics Technology Programming and Applications",McGraw Hill Co., New Delhi, 2012.* 2. *Deb .S.R, "Robotics technology and flexible automation", Tata McGraw Hill publishing company limited, New Delhi, 2010.* 3. *Klafter.R.D, Chmielewski.T.A and Noggins, "Robot Engineering: An Integrated Approach", Prentice Hal of India Pvt. Ltd., New Delhi, 2010.* 4. *Fu K.S, Gonzalez, R.C.,& Lee, C.S.G., "Robotics control, sensing, vision and intelligence", McGraw Hill Book Co., Singapore, Digitized 2007.*	5. *Craig.J.J, "Introduction to Robotics mechanics and control", Addison- Wesley, London, 2008.* 6. *References:* 7. *S. Mukherjee, Robotics, Khanna Book Publishing Co., New Delhi* 8. *S.K. Saha, Introduction to Robotics, TMH* 9. *T.C. Manjunath, Fundamentals of Robotics, Nandu Printers and Publishers Private Limited, Mumbai*

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 %	

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

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. BIJAY KUMAR ROUT, BITS, Pilani*	*V.RAGHAVENDRA RAO, SRMIST*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*SELVA KUMAR .S, FORD INDIA LIMITED, CHENNAI.*	*Dr. M. Iqbal, SRMIST*

Course Code	18MEO102T	Course Name	ALTERNATIVE SOURCES OF ENERGY	Course Category	E	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize with the solar energy technologies*
CLR-2 :	*Study the wind energy and hybrid energy systems*
CLR-3 :	*Be familiar with the concepts of ocean, hydro and geothermal energy systems*
CLR-4 :	*Familiarize with the biomass energy conversion technologies*
CLR-5 :	*Familiarize with the operations of direct energy conversion systems*
CLR-6 :	*Be familiar with alternative energy needs with its availability*

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 :	*Recognize and analyze the solar energy systems*	*1&2*	*90*	*80*	*H*	*M*		*M*										*H*	
CLO-2 :	*Acquire knowledge on wind energy conversion systems*	*1*	*90*	*80*	*H*	*M*	*M*	*L*			*M*							*H*	
CLO-3 :	*Understand the ocean, hydro and geothermal energy*	*1*	*90*	*80*	*H*						*M*							*H*	
CLO-4 :	*Understand and identify biologically degradable resources and its energy conversion processes*	*1&2*	*90*	*80*	*H*													*H*	
CLO-5 :	*Recognize the design needs for direct energy conversion systems*	*1&2*	*90*	*80*	*H*		*M*											*H*	
CLO-6 :	*Understand and renovate future energy needstowards renewable energy*	*1*	*90*	*80*	*H*	*M*	*M*				*M*							*H*	

		Solar Energy	Wind Energy	Ocean, Hydro and Geothermal Energy	Biomass	Direct Energy Conversion Systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Solar energy, Solar radiation and its measurements*	*Wind energy, Basic principle and Components of wind energy conversion system*	*Wave characteristics and wave energy conversion systems*	*Biomass,Sources of biomass*	*Basics of direct energy conversion systems, thermo electric and thermionic power generations*
S-2	SLO-1	*Types of solar thermal collectors*	*Wind data, site selection and energy estimation*	*Tidal energy and its types*	*Pyrolysis, combustion and gasification process*	*Fuel cell principles and its classification*
S-3	SLO-1	*Solar thermal applications for water heaters, solar stills and solar pond*	*Types of Horizontal axiswind turbine such as Single blade, Two blades,*	*Estimation of energy and power in single basin tidal system*	*Updraft and downdraft gasifier*	*Types - Phosphoric acid, polymer electrolyte membrane fuelcell, molten carbonate fuel cell and solid oxide fuel cell*
S-4	SLO-1	*Solar thermal applications for refrigeration and air conditioning system*	*Types of Horizontal axis wind turbine such as Multi blades, Dutch and Sail type*	*Ocean thermal energy conversion for open system*	*Fluidized bed gasifier*	*Fuel cell conversion efficiency and applications*
S-5	SLO-1	*Solar thermal applications for solar dryer, solar cookers and solar furnaces*	*Vertical axis wind turbinesuch as Savonius Rotor, Darrieus Type*	*Ocean thermal energy conversion for closed system.*	*Fermentation and digestion process*	*Open cycle magneto hydrodynamic power generation*
S-6	SLO-1	*Drawbacks/Real field issues in solar thermal systems, sensible and latent heat thermal energy storage systems to avoid day night issues*	*Design consideration of horizontal axis wind turbine*	*Hydro power plants for small, mini and micro system*	*Fixed and floating digester biogas plants*	*Closed cycle magneto hydrodynamic power generation*
S-7	SLO-1	*Solar thermal power generation systems*	*Aerofoil theory, Analysis of aerodynamic forces acting on the blade*	*Exploration of geothermal energy.*	*Design considerations of digester*	*Hydrogen energy: properties and its production methods*
S-8	SLO-1	*Solar photovoltaic systems: basic working principle, componentsand its applications*	*Performance of wind turbines*	*Geothermal power plants*	*Operational parameter of biogas plants, Economics of biomass power generation*	*Electrolysis, thermo-chemical, fossil fuels and solar energy methods*
S-9	SLO-1	*Performance assessment of any one solar thermal and electric systems*	*Hybrid energy systems (solar and wind),environmental issues of wind*	*Challenges, availability, geographical distribution, scope*	*Sources and production of biodiesel and ethanol*	*Hydrogen storage, transportation and applications*

			energy			

Learning Resources	1. *Godfrey Boyle, "Renewable energy", 2nd Edition, Oxford University Press, 2010* 2. *G.D Rai, "Non-Conventional Energy Sources", Khanna Publishers, 5th Edition, New Delhi, 2011* 3. *Twidell.J.W and Weir.A.D, "Renewable Energy Resources",1st Edition, UK,E.&F.N. Spon Ltd, 2006* 4. *Domkundwar.V.M, Domkundwar. A.V, "Solar energy and Non-conventional sources of energy",Dhanpatrai& Co. (P) Ltd, 1st Edition, New Delhi, 2010*	5. *B.H Khan, "Non-conventional Energy Resources", 2nd Edition, New Delhi, Tata McGraw Hill, 2009* 6. *S.P. Sukatme, J.K. Mayak, "Solar Energy-Principles of thermal collection and storage", 3rd edition,Newdelhi, McGraw Hill,2008* 7. *Tiwari.G.N, Ghosal.M.K, "Fundamentals of renewable energy sources",1st Edition, UK, Alpha ScienceInternational Ltd, 2007.* 8. *D. LE GOURIERES, "Wind Power Plants, Theory and Design", Pergamon, 1982.*

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	Faculty in-charges
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Mr.M.Periasamy *Chief Manager* *Neyveli New Thermal Power Project* *Email: mpsamy34912@gmail.com*	*Dr. K. R. Balasubramanian* *Associate Professor* *Department of Mechanical Engineering* *National Institute of Technology* *Email:krbala@nitt.edu*	*Dr. G. Balaji,* *SRM IST* *Email: balaji.g@ktr.srmuniv.ac.in*

Course Code	18MEO103T	Course Name	ENERGY SYSTEMS FOR BUILDINGS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the energy transfer in buildings*
CLR-2 :	*Study the solar passive heating and cooling systems*
CLR-3 :	*Be familiar with the lighting systems of buildings*
CLR-4 :	*Study the Heat control and ventilation methods in buildings*
CLR-5 :	*Be familiar with the Green buildings*
CLR-6 :	*Be familiar with the design and energy management of buildings*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO – 3
CLO-1 :	*Acquire knowledge on heating and cooling load calculations on energy efficient buildings*	*1,2 &3*	*90*	*80*	*H*	*M*		*M*										*H*	
CLO-2 :	*Understand the concept of solar passive heating and cooling*	*1,2*	*90*	*80*	*H*	*M*					*M*							*H*	
CLO-3 :	*Understand the concept of Day lighting and electrical lighting systems*	*1&2*	*90*	*80*	*H*					*L*	*M*							*H*	
CLO-4 :	*Recognize the design parameters influencing thermal design of buildings*	*1,2 &3*	*90*	*80*	*H*	*M*		*M*			*M*							*H*	
CLO-5 :	*Understand the concept of green buildings and certifications*	*1 &2*	*90*	*80*	*H*		*M*			*L*	*M*							*H*	
CLO-6 :	*Acquire knowledge on design and energy management of buildings*	*1,2 & 3*	*90*	*80*	*H*	*M*	*M*	*M*		*L*	*M*							*H*	

		Energy transfer in buildings	Passive solar heating & Cooling	Lighting systems of buildings	Heat control & ventilation	Green buildings
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concepts of energy efficient buildings*	*General principles of passive solar heating*	*Introduction to lighting systems of buildings*	*Introduction to heat control and ventilation*	*Introduction to green building*
S-2	SLO-1	*Conventional versus Energy Efficient buildings*	*Key design elements of passive heating*	*Glazing materials: Sources and concepts of optical materials*	*Design parameters influencing thermal design of buildings*	*Green building features and green construction materials*
S-3	SLO-1	*Climate and its influence in building design for energy requirement, Thermal properties of building materials*	*Direct solar heat gain by Trombe mass walls*	*Concepts of day lighting*	*Heat transmission through building sections*	*Green building rating tools*
S-4	SLO-1	*Codes and standards for the energy efficient buildings-ECBC codes*	*Passive cooling and its Key design elements, ventilation*	*Components of daylight factors and Recommended daylight factors*	*Effect of heating with orientation of buildings*	*Integrated ecological design, Sustainable site and landscaping*
S-5	SLO-1	*Energy balance for cooling and heating of buildings*	*Water walls, evaporative cooling*	*Day lighting analysis*	*Ventilation requirements for heat control in buildings*	*Indoor air quality, Water and waste management systems*
S-6	SLO-1	*Calculation of heating load, Heat losses and Internal heat sources*	*Convective air loops and solar chimney effects*	*Electrical lighting and Illumination requirement*	*Standards for ventilation*	*Green Globe, LEED, GRIHA, IGBC codes & certifications*
S-7	SLO-1	*Calculation of cooling loads of the building*	*Predicting ventilation in buildings, window ventilation calculations*	*Selection of luminaries and performance parameters*	*Ventilation designs, Energy conservation measurement*	*Standards for green building certifications*
S-8	SLO-1	*Low and zero energy buildings*	*Thermal insulation, load control, air filtration,*	*Electric lighting control for day lighted buildings*	*Natural ventilation methods*	*Economics, managing initial costs of green buildings*
S-9	SLO-1	*Future building design aspects*	*Odor removal and heat recovery in large buildings*	*Comparison of day and electrical lighting*	*Forced ventilation methods*	*Environment benefits of green buildings*

Learning Resources	1. *Means R.S., "Green building: project planning and cost estimating", Kingston, 2006* 2. *Kibert C.J., "Sustainable Construction: Green Building Design", 2nd edition, Wiley, 2007* 3. *Boecker J., Scot Horst, Tom Keiter, Andrew Lau, Markes Sheffer, Brian Toevs, Bill Reed, "Integrative Design Guide to Green Building", Wiley, 2009* 4. *Eicker U., "Low Energy Cooling for Sustainable Buildings", Wiley, 2009* 5. *Gevorkian P., "Alternative Energy Systems in Building Design", McGraw-Hill, 2010.*	6. *Harvey D.L., "Handbook on Low-Energy Buildings and District-Energy Systems", Earthscan, 2006.* 7. *Attmann O., "Green Architecture", McGraw-Hill, 2010* 8. *Kubba S., "Handbook of Green Building Design and Construction", Elsevier, 2012.* 9. *Majumdar, M., "Energy – Efficient Buildings in India", Tata Energy Research Institute, Ministry of Non-Conventional Energy Sources, 2002.* 10. *Energy Conservation Building Codes: www.bee-india.nic.in*

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. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. S. Suresh,* *Associate Professor,* *Dept. of Mechanical Engineering,* *National Institute of Technology,* *Tiruchirappalli - 620 015.*	*Dr. C. Selvam* *Assistant Professor,* *Department of Mechanical Engineering* *SRM IST* *Email: selvam.c@ktr.srmuniv.ac.in*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Mr. Cibi Chakravarthy N* *Assistant Engineering Manager-HVAC* *Engineering Design and Research Centre,* *L&T Construction, Mount Poonamallee Road,* *Manapakkam, Chennai-89.*	*Mr. P. Sundaram* *Assistant Professor,* *Department of Mechanical Engineering* *SRM IST* *Email: sundaram.p@ktr.srmuniv.ac.in*

Course Code	18MEO104T	Course Name	OPERATION RESEARCH	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the Objectives, Characteristics, Necessity, Scope, Applications of OR and LPP in simplex and to determine what resources are assigned to get most optimum output*
CLR-2 :	*Be familiar with the Applications of LPP in in determining resource allocation in existing business structures and in the decision making process of replacing a used equipment*
CLR-3 :	*Be familiar with the scheduling and operational problems in manufacturing, service and distribution*
CLR-4 :	*Know the waiting line models and all aspects of managing a company's inventories*
CLR-5 :	*Determine how decisions are made given unknown variables and an uncertain decision environment framework and how and why people make decisions*
CLR-6 :	*Familiar with resource management techniques and its applications in industries*

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 Concepts of Linear programming technique*	*1&2*	*90*	*85*	*M*	*H*	-	*M*	-	*L*	-	-	-	-	*M*	-	*H*	*H*	*M*
CLO-2 :	*Learn the applications of Transportation and Replacement models*	*1*	*90*	*85*	*M*	*H*	-	*M*	-	*L*	-	-	-	-	*M*	-	*H*	*H*	*M*
CLO-3 :	*Study the various Techniques of scheduling and sequencing*	*1*	*90*	*85*	*M*	*H*	-	*M*	-	*M*	-	-	-	-	*L*	-	*H*	*H*	*M*
CLO-4 :	*Gain detailed knowledge of Inventory control and Queuing theory*	*1&2*	*90*	*85*	*M*	*H*	-	*M*	-	*M*	-	-	-	-	*H*	-	*H*	*H*	*M*
CLO-5 :	*Understand the techniques involved in Decision theory and Game theory*	*1&2*	*90*	*85*	*M*	*H*	-	*L*	-	*M*	-	-	-	-	*M*	-	*H*	*H*	*M*
CLO-6 :	*Learn resource management techniques to manage resources multiple departments and projects*	*1&2*	*90*	*85*	*M*	*H*	-	*M*	-	*M*	-	-	-	-	*M*	-	*H*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Operation Research and decision making- Development, Definition, Characteristics, Necessity, Scope, Applications, Advantages, Limitations*	*Assignment models [Balanced, Unbalanced, Maximization]*	*Problem of Sequencing, Processing 'n' jobs through two and three machines.*	*Introduction – Necessity for Maintaining Inventory, Inventory Costs – Types- Variables in an inventory problem – Lead time, Reorder Level, EOQ*	*Steps in Decision theory approach - Decision making Environments - Making under conditions of Certainty, Uncertainty, Conditions of Risk*
S-2	SLO-1	*Objectives, Phases, Types of mathematical models in OR and constructing the model. Linear Programming - Requirements, Assumptions, Advantages, Limitations, Applications*	*Assignment models - Travelling Salesman Problem (Shortest Cyclic Route Models)*	*Problem of Sequencing, Processing 'n' jobs through two and three machines.*	*Deterministic Inventory Models – Purchasing model with no shortages, Manufacturing model with no shortages*	*Steps in Decision theory approach - Decision making Environments - Making under conditions of Certainty, Uncertainty, Conditions of Risk*
S-3	SLO-1	*Formulation of linear programming problem, Simplex method - Graphical method of Solution*	*Transportation problem – Assumption, Definition, Formulation and Solution - North west corner method, Least cost method, Vogel's approximation method.*	*Project - Planning, Scheduling, Controlling – Network Analysis – Constructing a project network - Fulkerson's Rule*	*Purchasing model with shortages, Manufacturing model with shortages*	*Decision making conditions – problems*
S-4	SLO-1	*Simplex method - Analytical - Canonical and Standard forms of LPP*	*Transportation problem – MODI method*	*Network computations – Earliest Completion time of a project and Critical path, Floats*	*Multi item deterministic model, safety stock, storage quantity discount*	*Decision trees. - Utility Theory*
S-5	SLO-1	*Artificial Variables Techniques - Big M-method*	*MODI method [balanced in transportation model]*	*Programme Evaluation Review Technique*	*Problems in Multi item deterministic model*	*Problems in Decision trees*
S-6	SLO-1	*Artificial Variables Techniques - Two Phase method*	*MODI method [Unbalance in transportation model]*	*Total Slack, Free Slack, Probability of achieving completion date*	*Queuing Models - Elements - Kendall's Notation – Poisson arrivals and*	*Theory of Games , Characteristics Game models -Definition - Rules - Pure*

					exponential service times	*Strategy*
S-7	SLO-1	*Problems in Artificial Variables Techniques*	*Replacement Model, Replacement of items that deteriorate, Gradually, Fail suddenly*	*Cost Analysis - Crashing the network*	*Waiting time, Idle time cost, Single channel problem*	*Optimal solution of two person zero sum games, mixed strategies*
S-8	SLO-1	*Sensitivity analysis – Change in objective function*	*Group Replacement policy analysis - Problems*	*Resource Scheduling - Advantages, Limitations*	*Multi-channel problem*	*Graphical solution of (2xn) and (mx2) games*
S-9	SLO-1	*Sensitivity analysis – Change in the availability of resources*	*Group Replacement policy analysis - Problems*	*Vehicle routing problems*	*Poisson arrivals and service time*	*Solution of (mxn) games by linear programming*

Learning Resources	*1. Premkumar Gupta and Hira, "Operation Research", Third Edition S Chand Company Ltd., New Delhi 2014.* *2. A.C.S.Kumar, "Operation Research", Yes Dee Publishing Ltd., Chennai 2015.* *3. Fredric.S.Hilleer and Gerold J. Lieberman, "Introduction to Operation Research", 10th Edition, 2014.* *4. Handy, "A. Taha, "Operations Research", 10th Edition, Prentice Hall of India, New Delhi, 2016.*	*5. Philip and Ravindran, "Operational Research", John Wiley, 2000.* *6. Sundaresan.V, GanapathySubramanian.K.S, "Resource Management Techniques:Operations Research" A.R Publications, 2003.* *7. Panneerselvam.K, "Operation Research", Prentice Hall of India, 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. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr. Rajendran C , IITM*	*1. Mr. S. Oliver Nesa Raj, SRMIST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr. Srinivasan G , , IITM*	*2. Dr. P. Godhandaraman, SRMIST*

Course Code	18MEO105T	Course Name	MATERIALS MANAGEMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To Understand the principles of materials Management*
CLR-2 :	*To Acquire knowledge on Inventory control and materials forecasting*
CLR-3 :	*Be familiar with the Material planning and control*
CLR-4 :	*Be familiar with the Storage and distribution*
CLR-5 :	*To attain the knowledge about material accounting and budgeting*
CLR-6 :	*Be familiar with the basic aspects of Material Management, Inventory control procedures, Codification of materials, Online material management system.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the Materials management and to recognize the relationship with other functional areas and acquire the knowledge on inventory control and material forecasting*	*1&2*	*90*	*85*	*H*						*M*								
CLO-2 :	*Acquire knowledge on Inventory control and materials forecasting*	*1*	*90*	*85*	*H*						*M*								
CLO-3 :	*Appreciate the Job evaluation and understand the need of scheduling*	*1*	*90*	*85*	*H*						*M*					*L*			
CLO-4 :	*Understand the theory behind the Project management and acquire the knowledge about MRP, Storage design and storage system and layout*	*1&2*	*90*	*85*	*H*										*L*				
CLO-5 :	*Obtained the knowledge about Materials management controls, Budgetary control*	*1&2*	*90*	*85*	*M*									*L*					
CLO-6 :	*Recognize the use of materials management, acquire knowledge on the inventory management and control procedures, Codification of materials, Online material management system,Purchasing policies and procedures*	*1&2*	*90*	*85*	*M*						*M*								

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History and development of material management, Policy manual: A to Z items*	*Materials forecasting, Selection of inventory control, BOM*	*Codification of materials Storage systems and equipment*	*Purchasing policies and procedures*	*Performance indicators*
S-2	SLO-1	*Concept and details of integrated materials and management systems*	*Spare parts managements and techniques*	*Storage design, Stores layout*	*Legal aspects of purchasing*	*Materials management controls*
S-3	SLO-1	*Important and scope of materials management*	*Inventory control systems, Lead time analysis, Optimum order quantity*	*Storage systems and equipments*	*Selection of sources of supply*	*Budgetary control*
S-4	SLO-1	*Materials purchase policy and economic ordered quantity*	*Types of Lead time; Administrative lead time, Supplier lead time, Transport lead time*	*Stores preservation*	*Vendor evaluation and rating*	*Computer in materials management, Computer revolution, Software and hardware, Materials information system*
S-5	SLO-1	*Purchasing cycle, A to Z purchase order*	*Flow charting techniques to reduce various types of lead time*	*Stores procedures Stock valuation and verification*	*Vendor development, Price and Cost analysis*	*Reports and information needs, Application and limitations of computers in materials management*
S-6	SLO-1	*Functions of Materials Intelligence (MIS)*	*Aggregate inventory management*	*Ware housing Distribution management*	*Ethical buying, Ethical concept in buying*	*Store functions, types of Sores, sore identification systems*
S-7	SLO-1	*Specification and Standardization in Materials Management*	*Problems in Inventory control*	*Store accounting*	*Purchasing organisations, Purchasing cycle and contracts*	*Store accounting, sore records, Legal aspects of sore keeping*
S-8	SLO-1	*Make or buy decision, buying process*	*Materials requirement planning*	*Material handling system and equipments*	*Sourcing supplier evaluation*	*Online material management system*
S-9	SLO-1	*Purchasing cycle and economic ordered quantity*	*Supply chain Management*	*Need for inventory, Inventory cost, Inventory control measures(ABC, XYZ analysis)*	*Legal aspects of purchasing*	*Coding of materials, material purchasing policies and procedures*

Learning Resources	1. *"Operations and Supply Chain Management" Ann K. Gatewood, Publisher: Pearson 8 editions, January 2016.* 2. *"Introduction to Materials Management" , Tony K. Arnold, 8th Edition by Steve Chapman, , Publisher Pearson edition, 2017* 3. *"Inventory Accuracy: People, Processes, & Technology, OPS Publishing; 1 edition, March 2003.* 4. *"Operations Management, Mahadevan B, Publisher: Pearson 3rd edition,2017.*	5. *"Purchasing and Materials Management", Gopalakrishnan.P, Tata McGraw Hill Education, 01-Mar-2001.* 6. *"Materials Management: An Integrated Systems Approach" Publisher: Springer original 1st edition, 2014.* 7. *"Material Management an integrated approach" Publisher, PHL Learning Private Limited, 3rd edition,2011* 8. *"Production and operations management", SN.Chary, Tata McGraw Hill Education, 5th edition, 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 %*	-	*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
Mr.Samsudin-ATI-Chennai	*Dr.B.S.MURTY-IIT MADRAS*	*Mr.R.Saravanakumar*
Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.K.G.Pradeep-IIT MADRAS*	*Mr. Selwyn Jebadurai*

Course Code	18MEO106T	Course Name	ENVIRONMENTAL POLLUTION AND ABATEMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be Familiar the principles and methods of controlling various types of pollution.*
CLR-2 :	*Understand the emission control techniques.*
CLR-3 :	*understand water treatment and solid removal methods*
CLR-4 :	*Be Familiar with aerobic and anaerobic treatments.*
CLR-5:	*Be Familiar with the nature of solid waste and their disposal.*
CLR-6	*understand the environmental pollutants and theircontrol*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	*Understand the basics of pollution and the control methods*	*1,2*	*90*	*80*
CLO-2 :	*Acquire knowledge aboutvarious air pollutants and emission control techniques.*	*1,2*	*90*	*80*
CLO-3 :	*Understand the water treatment methods and solid removal*	*1,2*	*90*	*80*
CLO-4 :	*Acquire knowledge about the Aerobic and anaerobic treatments*	*1,2*	*90*	*80*
CLO-5 :	*Acquire knowledge about the variousSolid waste disposal methods.*	*1,2*	*90*	*80*
CLO-6 :	*Acquire knowledge about the environmental pollution and control*	*1,2*	*90*	*80*

		Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Understand the basics of pollution and the control methods*	*H*						*L*								
CLO-2 :	*Acquire knowledge aboutvarious air pollutants and emission control techniques.*	*H*					*M*	*H*								
CLO-3 :	*Understand the water treatment methods and solid removal*	*H*						*H*								
CLO-4 :	*Acquire knowledge about the Aerobic and anaerobic treatments*	*H*						*H*								
CLO-5 :	*Acquire knowledge about the variousSolid waste disposal methods.*	*H*					*M*	*H*								
CLO-6 :	*Acquire knowledge about the environmental pollution and control*	*H*					*M*	*H*								

		Basics of Pollution and Prevention	Air Pollution	Water Pollution	Biological Treatment	Solids disposal
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Environment and environmental pollution from chemical process industries, characterization of emission and effluents*	*Sources and formation of Sulfur oxides (SOx); nitrogen oxides (NOx), carbon monoxide*	*Biological uptake of pollutants*	*Anaerobic degradation of organic matter*	*Solids waste disposal – composting process and its phases*
	SLO-2	-	*total suspended particulate matter, respirable particulates*			
S-2	SLO-1	*environmental Laws, rules and standards for ambient air*	*photo-chemical oxidants. Other pollutants*	*effect of pollutants on land, vegetation, animals and human health*	*Trickling filter – Process description*	*Sanitary landfill- Principle and process*
S-3	SLO-1	*noise pollution- effects, control*	*Green house effect,green house gases: CO_2, CH_4, N_2O, CFCs,*	*bio-deterioration, bioaccumulation*	*aerobic treatment – aeration units*	*gasification process.*
	SLO-2	-	*water vapor concentration, alternatives for CFCs, global warming and climate change*	-		
S-4	SLO-1	*Process modification: alternative raw material, recovery of by product*	*ozone layer depletion- ozone depleting processes, ozone hole,*	*bio-magnification and eutrophication*	*biochemical kinetics: Hydraulic detention time, Mean residence time*	*Upward, Downward, cross draft gasifier*
	SLO-2		*environmental effects and strategies for ozone layer protection,*			
S-5	SLO-1	*recycle and reuse of waste, energy recovery and waste utilization*	*acid rain-sources and impact*	*infectious microbial agents in water system*	*Types of activated sludge process*	*Incineration and Pyrolysis*
	SLO-2					
S-6	SLO-1	*Material and energy balance for pollution minimization.*	*wet gas scrubbing techniques*	*consequences on human health.*	*Tapered aeration*	*Quantum and nature of solid waste*
	SLO-2					
S-7	SLO-1	*Water use minimization*	*gaseous emission control by absorption and adsorption methods*	*Physical treatment- pre-treatment*	*Stepped aeration*	*bio methanation -phases involved and factors*
	SLO-2					

S-8	SLO-1	*Fugitive emission, effluents and leakages*	*Design of cyclones, Electrostatic Precipitation*	*solids removal by settling and sedimentation*	*sludge separation*	*Pelletization, landfill and gas recovery*
	SLO-2					
S-9	SLO-1	*Pollution control through housekeeping and maintenance..*	*fabric filters and absorbers*	*filtration and centrifugation*	*Aerobic treatment units (ponds,lagoons, oxidation ditch)*	*municipal solid waste disposal- Best management practices for containers*
	SLO-2			*coagulation and flocculation.*		

Learning Resources	*1. Vallero D; "Fundamentals of Air Pollution", 4 th Ed; Academic Press, 2008* *2. Eckenfelder W.W; "Industrial Water Pollution Control", 2 Ed; McGraw Hill, 2000* *3. Kreith F. and Tchobanoglous G., "Handbook of Solid Waste Management", 2 Ed; Mc Graw Hill, 2002*	*4. Pichtel J; "Waste Management Practices: Municipal,Hazardous and Industrial", CRC, 2005* *5. Tchobanoglous G., Burton F. L. and Stensel H.D., "Waste Water Engineering: Treatment and Reuse", 4th Ed; Tata McGraw Hill,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	*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, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr. S.K. Rani* *Professor & Dean (SP & CS)* *Crescent Institute of Science and Technology*	*V. Praveena* *Assistant Professor*
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*M Malathi* *Manager R &D, IP Rings*	*Dr. P. Chandrashekaran* *SRMIST*

Course Code	18MEO107T	Course Name	NANO ROBOTICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the basics of Robotics and Nano Technology*
CLR-2 :	*Be familiar with the Micro/Nano Sensors*
CLR-3 :	*Be familiar with the Micro/Nano Actuators*
CLR-4 :	*Be familiar with the Micro/Nano Manipulators*
CLR-5 :	*Be familiar with the Micro/Nano Robotics manufacturing and control techniques*
CLR-6 :	*Familiar with the Micro/Nano Sensors, Actuators, Manipulators and Manufacturing Techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	*Acquire knowledge on Basics of Robotics and Nano Technology*	*1*	*90*	*85*
CLO-2 :	*Understand the various Micro/Nano Sensors*	*1&2*	*90*	*85*
CLO-3 :	*Understand the Micro/Nano Actuators*	*1&2*	*90*	*85*
CLO-4 :	*Understand the Micro/Nano Manipulators*	*1&2*	*90*	*85*
CLO-5 :	*Acquire knowledge on Micro/Nano Robotics manufacturing and control techniques*	*1*	*90*	*85*
CLO-6 :	*Learn Micro/Nano Sensors, Actuators, Manipulators and Manufacturing Techniques*	*1&2*	*90*	*85*

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

		Fundamentals of Robotics and Nanotechnology	Micro/Nano Sensors	Micro/Nano Actuators	Micro/Nano Manipulators	Micro/Nano Robotics manufacturing and control techniques
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-History of Robotics*	*Far field and Near filed Imaging sensors*	*Bending type Piezoelectric actuators*	*SPM Probes and Micro nano grippers*	*CAD models and CAD models of nanostructures*
S-2	SLO-1	*Robot Anatomy and Work Volume*	*Position and Capacitive sensors*	*Unimorph, Bimorph and stack type actuators*	*Atomic manipulation using STM*	*Micro nano assembly and Self assembly*
S-3	SLO-1	*Robot Drive Systems*	*Linear Variable Differential Transformer*	*Piezo tube and Thin film types ZnO*	*Optical Tweezers*	*Precision micro/nanoparticle assembly using SEM*
S-4	SLO-1	*End Effectors and Robotic Sensors*	*Interferometric sensors*	*Surface acoustic waves and Elecrostatic actuators*	*Dielectrophoresis*	*Guided Self Assembly*
S-5	SLO-1	*Actuators and Power transmission system*	*Accelerometers and Gyroscopes*	*Thermal and Ultrasonic actuators*	*Bio manipulation*	*Automated manipulation of nanoparticles*
S-6	SLO-1	*Importance of Nanotechnology-History of Nanotechnology*	*Force, Pressure Sensors*	*Electro and Magnetostrictive based actuators*	*Slip motion (nanomanipulation)*	*Micro Mechanical Flying robot*
S-7	SLO-1	*Opportunity at the nano scale-length and time scale in structures*	*Chemical and Flow sensors*	*Shape memory alloy actuators*	*Carbon nanotube manipulation using nanoprobes*	*Kinematics and Dynamics of Robot*
S-8	SLO-1	*Nano device structures*	*Strain gauge and Deflection based AFM*	*Polymer actuators, Dielectric elastomers*	*High density data storage using nanoprobes*	*Kinematics and Dynamics of Robot*
S-9	SLO-1	*Overview of Nano robotics system Components*	*Visual force sensing, Bending imaging and Tactile sensors*	*CNT actuators and Bimolecular Motors*	*Simple case study*	*Teleoperation based, Task based and automatic control robot*

Learning Resources	1. *Norio Taniguchi, "Nanotechnology", Oxford university press, Cambridge, 1996.* 2. *Ning Xi, Guangyoung Li, "Introduction to Nanorobotic Manipulation & Assembly" Artech House press 2012* 3. *Elwenspoek.M and Wiegerink.R., "Mechanical Microsensors", Springer-Verlag Berlin, 2001.*	4. *Fatikow.S. Rembold.U., "Microsystem Technology and Microrobotics", Springer Verlag, 1997* 5. *Bhushan.B., "Handbook of Micro/Nanotribology", CRC Press, 2nd Ed., 1999.*

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. Dinesh kumar, TAFE India Pvt Ltd, Chennai	*1. Dr. V.Srinivasan,Annamalai University, srinivraghavan@yahoo.com*	*Mr.S.Dinesh,SRM IST*
2. Mr. K.Nivasraj, Vedanta ltd, Goa	*2. Dr.Assaithambi, Govn. Col.of. Eng,sengipatti,Thanjavur, basaithambi@gcetj.edu.in*	*Mr.N.Karthikeyan, SRM IST*

Course Code	18MEO108T	Course Name	AUTOMATIC CONTROL SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the history of control systems, relevance of input and output transfer function.*
CLR-2 :	*Impart the knowledge on principles involved in modeling various mechanical and state space representations of systems.*
CLR-3 :	*Gain knowledge on steady state and transient state response and stability criterion*
CLR-4 :	*Know application of various tools used for stability analysis of various systems*
CLR-5 :	*Understand upon Discrete control systems and Z transformations*
CLR-6 :	*Impart knowledge on developing a system and studying on the stability of the system using various 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 :	*model systems that are applied to the reality*	*1& 2*	*80*	*85*	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*understand response analysis*	*1*	*80*	*85*	*H*	*M*	*H*			-	-	-	-	-	-	-	-	-	-
CLO-3 :	*understand the basic tools of analysis and stability*	*1*	*80*	*85*	*H*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*understand the basic tools of analysis and stability*	*1&2*	*80*	*85*	*H*	*M*	-	-	*M*	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*understand basic concepts in digital controls*	*1&2*	*80*	*85*	*H*	*H*	-	*M*		-	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand the systems and their model creation and utilization of various tools in analyzing the responses of various realistic systems*	*1&2*	*80*	*85*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	-	-	-

		Introduction	Modeling systems	Analysis of system status - stability	Tools for Analysis of stability	Discrete Control systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Controls – definition – need for control – examples*	*Principles of modeling – common aspects of all mechanical systems – components – common features*	*Transient analysis*	*Routh criteria for stability*	*Discrete control systems – concepts – back ground - introduction*
S-2	SLO-1	*necessity of controls for engineers*	*Development of model – Mechanical systems*		*Root locus – background*	
S-3	SLO-1	*History of control systems*	*Development of model – Electrical systems*	*Steady state analysis*	*Root locus – construction – simple systems*	*Basic components of discrete systems – quantization and errors*
S-4	SLO-1	*Theory, design and engineering*	*Development of model – Electrical systems*		*Root locus – complex systems*	
S-5	SLO-1	*Basic open loop system,*	*Linearization of nonlinear systems*	*Error identification – analysis*	*Bode plots – concept – simple systems*	*Concepts behind Z-transforms – basic functions -*
S-6	SLO-1	*Concept of feedback, closed loop system*	*State space representation – relationship to transfer function*			
S-7	SLO-1	*Relevance of relationship between input – output – transfer function*	*Use of state space representation*	*Position – velocity – acceleration error constants*	*Construction of bode plots*	*Impulse sampling and data hold In Discrete Control systems*
S-8	SLO-1	*Block diagram - drawing handling - components*	*Summarizing system modeling*			
S-9	SLO-1	*Historical examples of control systems*		*Routh criteria for stability*	*Introduction to compensation and design of control systems*	

Learning Resources	1. *Automatic control systems , Benjamin kuo, Wiley publication , Ninth edition ,2014* 2. *Modern control engineering, Ogata.K, Prentice Hall, Fifth Edition, 2010* 3. *Discrete time control systems, Ogata.K, Prentice Hall, 1995*	4. *Control Systems, Gopal, Tata McGraw-Hill 3rd edition , 2007.* 5. *Modern Control Engineering, Nagrath& Gopal, New Age International,2014* 6. *Control Systems, A. Ambikapathy, Khanna Publishing House,2018.* 7. *V.I. Goerge, Digital Control Systems, Cengage, 2014.*

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.

INDUSTRIAL EXPERT	ACADEMIC EXPERT	INTERNAL EXPERT
SELVA KUMAR .S, FORD INDIA LIMITED, Chennai	*Dr. BIJAY KUMAR ROUT, BITS, Pilani*	*VASANTHKUMAR.CH , SRMIST*
Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	*Dr.R.Prabhusekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*Dr. S. Prabhu, SRMIST*

Course Code	18MEO109T	Course Name	NEURAL NETWORK AND FUZZY SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart the knowledge of neural network and fuzzy systems*
CLR-2 :	*Understand the various neural network algorithms*
CLR-3 :	*Initialize fuzzy logic and neuro fuzzy logic techniques*
CLR-4 :	*Familiarize with fuzzy algorithms*
CLR-5 :	*Enhance the knowledge of fuzzy & neural in various applications*
CLR-6 :	*Familiarize with genetic algorithm*

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 basic understanding of the various algorithms involved in Neural Networks & Fuzzy Systems*	*1,2*	*90*	*85*	*H*	*L*	*M*	*H*	*M*						*L*	*H*	*H*	*H*	-
CLO-2 :	*Acquire basic understanding of the various learning methods and methodologies*	*1,2*	*90*	*85*	*H*	*L*	*H*	*H*	*H*						*M*	*M*	*H*	*H*	-
CLO-3 :	*Understand various fuzzy algorithms*	*1,2*	*90*	*85*	*H*	*M*	*H*	*H*	*H*						*L*	*H*	*H*	*H*	-
CLO-4 :	*Analyze how to apply the concept of fuzzy & neural in mechanical applications*	*2,3*	*90*	*85*	*H*	*H*	*H*	*H*	*H*	*M*		*M*	*M*			*H*	*H*	*H*	-
CLO-5 :	*Application of neural and neuro fuzzy concepts*	*2*	*90*	*85*	*H*	*H*	*H*	*M*	*M*			*M*			*M*	*H*	*H*	*H*	-
CLO-6 :	*Acquire knowledge of Genetic Algorithm*	*1,3*	*90*	*85*	*H*	*L*	*H*	*H*	*H*				*M*		*M*	*H*	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Neural networks - Biological foundations*	*Learning Algorithms:Learning process – Supervised and unsupervised learning*	*Introduction to Fuzzy Logic: Fuzzy sets – Definition, Basic set – Theoretic operations for fuzzy sets*	*Fuzzy Logic and Control System: Fuzzy logic controller logic*	*Neuro-Fuzzy Logic Control –Optimization of membership function*
S-2	SLO-1	*ANN models, Types of activation functions*	*Error-correction learning*	*Fuzzy Relations on sets and fuzzy sets, Compositions of fuzzy relations*	*Fuzzification interface*	*Rules base of fuzzy logic controller using neural networks*
S-3	SLO-1	*Introduction to network architectures*	*Hebbian learning & Boltzmann learning*	*Properties of the Min-max Composition*	*Knowledge base and Decision making*	*Type A - Membership Model*
S-4	SLO-1	*Single layered systems*	*Single layer and multilayer preceptors*	*Fuzzy conditional statements*	*Defuzzification interface*	*Type A - Membership Model*
S-5	SLO-1	*Multilayer feed forward network(MLFFN)*	*Least mean square algorithm*	*Fuzzy rules*	*Fuzzy controller - Types*	*Type B – Membership Model*
S-6	SLO-1	*Radial basis function network(RBFN)*	*Back propagation algorithm*	*Fuzzy analysis – Fuzzy functions on fuzzy sets*	*The Mamdani Controller*	*Type B – Membership Model*
S-7	SLO-1	*Recurring neural network(RNN)*	*Applications in forecasting*	*Integration of fuzzy functions*	*The Sugeno Controller*	*Adaptive fuzzy systems*
S-8	SLO-1	*Advanced neural network – Hopfield nets algorithm*	*Applications in pattern recognition*	*Fuzzy Graphs*	*Application of fuzzy logic – Crane control*	*Adaptive neuron-fuzzy inference system (ANFIS)*
S-9	SLO-1	*Bumptree network algorithm*	*Applications in other engineering problems*	*Fuzzy Differentiation*	*Application of fuzzy logic – Control of a Model Car*	*Empirical research on aggregators*

Learning Resources	
	1. *Patricia Melin, "Modular Neural Networks and Type-2 Fuzzy systems for pattern recognition" Springer, 2012.*
	2. *James M. Keller, Derong Liu, David B. Fogel, "Fundamentals of computational intelligence. Neural Networks, Fuzzy systems, and evolutionary computation" IEEE Press, John Wiley & Sons, Inc., New Jersey, 2016.*
	3. *Cornelius T. Leondes, "Fuzzy logic and Expert systems applications" Academic Press, USA, 1998.*
	4. *Jacek.M.Zurada, "Introduction to artificial Neural Systems" Jaico Publishing House, Mumbai, 2007.*
	5. *Simon Haykins, "Neural Networks – A comprehensive foundation" Macmillan College, Pro.Con.Inc. New York, 2005.*
	6. *Zimmermann.H.J. "Fuzzy set theory and its applications" Allied Publication Ltd., Chennai, 2001.*
	7. *Tsoukalas.L.H and Robert E. Uhrig, "Fuzzy and Neural approach in Engineering" John Wiley and Sons, New York, 1997.*
	8. *Klir.G.J and Yuan.B.B. "Fuzzy sets and fuzzy logic" Prentice Hall of India, New Delhi, 1997.*
	9. *Driankov.D, Hellendron.H and Reinfrank.M, "An introduction to fuzzy control" Narosa Publishing House, New Delhi, 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, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*1. Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*1. Dr. M. R. Stalin John, SRMIST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2.Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*2. Mrs. I. Infanta Mary Priya, SRMIST*

Course Code	18MEO110T	Course Name	ROBOTIC SENSORS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
CLR-1 :	*Understand the basis of latest technology of sensors used in robots*			
CLR-2 :	*Be familiar with the concept Different sensing variables that are used as input to robots for sensing*			
CLR-3 :	*Impart the knowledge on various vision sensors applied in robots , vision systems and their overview*			
CLR-4 :	*Various methods used in robot programming*			
CLR-5 :	*Different types of grippers and gripping methods*			
CLR-6 :	*Understand various sensors used in robots and various programming methods in robotics, application of various grippers and their design concepts*			

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 :	*Understand the application of sensors in robotics*	*1& 2*	*80*	*70*
CLO-2 :	*Recognize the application of various inertial sensors, displacement measurement sensors, force and touch sensors in robotic applications*	*1*	*80*	*70*
CLO-3 :	*Understand various miscellaneous sensors and recognize the importance of telepresence and related technologies*	*1*	*80*	*70*
CLO-4 :	*Understand the controlling methodologies for a robot using vision sensor modules, and be able to understand robot vision locating position. Application of End effector camera sensor in robotics.*	*1&2*	*80*	*70*
CLO-5 :	*Recognize the various Control Computer configurations, Vision Sensor modules, Software Structure, Vision Sensor software structures and integration of all together for specific applications*	*1&2*	*80*	*70*
CLO-6 :	*Various sensors and their working principles in various robotic application, especially inertial sensors, force and other touch related sensors, miscellaneous sensors, vision sensors, telepresence and related technologies*	*1&2*	*80*	*70*

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*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*H*	*L*	*M*	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	*H*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		10	10	10	10	10
S-1	SLO-1	*An Introduction to sensors and Transducers, History and definitions*	*Position sensors – Optical, non-Optical*	*Different sensing variables*	*Introduction to vision sensor, working and principles of vision sensing*	*Control Computer for robot, Speciation's, Hardware requirements*
S-2	SLO-1	*Smart Sensing, working of a smart sensor, networking of smart sensors*	*Contact, non-contact type sensors position sensing*	*Smell and smart e-nose sensors*	*classification of vision sensors*	*Vision Sensor modules*
S-3	SLO-1	*AI sensing, Need of sensors in Robotics*	*Range Sensing, types and classification based on the Distance measurement technique*	*Heat or Temperature Humidity classification of RTD and Thermocouples Non-contact-based temperature measurement Pyrometry and Active, passive type of IR devices*	*Considerations for camera , and camera specifications*	*Software Structure,*
S-4	SLO-1	*Case study on AI*	*Touch and Slip sensors application in grippers as a feedback device*	*Light sensors and application of light sensors in robotic interlocks eg (as an interlock switch during power failure)*	*Integration of vision sensors to robot controller*	*Vision Sensor software,*
S-5	SLO-1	*Classification of various sensors*	*Sensors types of touch and slip sensors , tactile sensors*	*Speech or Voice recognition Systems,*	*End effector camera Sensor.*	*Robot programming,*
S-6	SLO-1	*Based on operation principle*	*Force sensors and their application in fixed robots*	*Speaker dependent voice recognition systems Speaker independent voice recognition system*	*Calibration of vision sensors*	*Handling, Gripper, classification of grippers based on operation*
S-7	SLO-1	*Based on application*	*Torque Sensors and associated circuitry used for torque sensors*	*Discrete speech recognition, Continuous speech recognition, Natural language processing system*	*Robot Control through Vision sensors*	*Gripping methods, accuracy*
S-8	SLO-1	*Sensors in mobile and fixed robot*	*Velocity sensors*	*Case study on voice recognition system (eg.*	*Robot vision locating position,*	*A Case study-01*

		configurations		*siri, Google talk)*		
S-9	SLO-1	*Application of sensors in various robots*	*Accelerometers*	*Need for telepresence*	*Robot guidance with vision system*	*A Case study-02*
S-10	SLO-1	*Case study on fixed robot configurations and mobile robot configurations*	*Proximity Sensors*	*Telepresence and related technologies.*	*End effector camera Sensor*	*A Case study-03*

Learning Resources	1. *Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.* 2. *John Iovice, "Robots, Androids and Animatrons", Mc Graw Hill, 2003.* 3. *K.S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics – Control Sensing, Vision and Intelligence", Tata McGraw-Hill Education, 2008.* 4. *Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, Tata McGraw-Hill Education, 2012.*	5. *Sabrie Soloman, Sensors and Control Systems in Manufacturing, McGraw-Hill Professional Publishing, 2nd Edition, 2009.* 6. *7. Julian W Gardner, Micro Sensor MEMS and Smart Devices, John Wiley & Sons, 2001.* 7. *John Iovice, "Robots, Androids and Animatrons", Mc Graw Hill, 2003.*

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
SELVA KUMAR .S	*Dr. BIJAY KUMAR ROUT*	*VASANTHKUMAR.CH*
SENIOR ANALYST, FORD INDIA LIMITED CHENNAI.	*Birla Institute of Technology and Science (BITS), Pilani, Rajasthan, Professor in the Department of Mechanical Engineering*	*Assistant Professor, Mechanical Engineering Department, SRMIST, KTR Campus.*

Course Code	18MEO111T	Course Name	INDUSTRIAL ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the techniques and procedures of work study*
CLR-2 :	*Know about various plant layout and material handling systems*
CLR-3 :	*Understand the ergonomics, production and productivity measurement*
CLR-4 :	*Impart the concept of production planning and control*
CLR-5 :	*Be familiar with methods of wage payment*
CLR-6 :	*Improve the efficiency, productivity and quality of products manufactured.*

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 knowledge on different techniques and procedures of work study*	*1*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-2 :	*Recognize the various plant layouts, need for site selection and about material handling*	*1&2*	*90*	*85*	*H*	-	-	-	*H*	-	-	-	-	-	-	-	*M*	-	-
CLO-3 :	*Acquire knowledge on ergonomics of work design, types and function of production and productivity measurement*	*1&2*	*90*	*85*	*H*	*M*	*H*	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Understand inventory management and resource utilization.*	*1&2*	*90*	*85*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-5 :	*Acquire knowledge on job evaluation, incentive schemes and method of wage payment*	*1*	*90*	*85*	*H*	*M*	-	-	-	-	-	*L*	-	-	-	-	-	-	*M*
CLO-6 :	*Analysis and improve the efficiency and productivity in the industries*	*1&2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Work measurement and its Techniques*	*Plant location and site selection.*	*Introduction to work design, Work design for increased productivity*	*Objectives and Functions of PPC*	*Types of Wages and salary administration*
S-2	SLO-1	*Production study and Time study.*	*Types, need, factors influencing the plant layout.*	*The work system, design Introduction to job design.*	*Aspects of product development and design*	*Meaning principles in wage fixation, Techniques used of wage fixation*
S-3	SLO-1	*Standard time, Rating factors and Work sampling.*	*Tools and techniques for developing layout, process chart, flow diagram, string diagram, Template and Scale models.*	*Environmental factors and organizational factors*	*Introduction to Process Planning and types, Principles of Standardization*	*Method of Job evaluation*
S-4	SLO-1	*Techniques of Work study*	*Layout Planning and procedure involved in creating layout*	*Behavioral factors influencing effective job design.*	*Break even analysis*	*Steps involved in merit rating of employee*
S-5	SLO-1	*Human factors of Work study*	*Construction and Improvement algorithms-Automated Layout Design Program (ALDEP)*	*Ergonomics, Objectives system approach of ergonomic model*	*Introduction to Group Technology. and various types*	*Various Methods of wage payment*
S-6	SLO-1	*Method study, Techniques and procedures of improving Productivity.*	*Construction and Improvement algorithms-Computerized Relative Allocation of Facilities Techniques(CRAFT)*	*Man machine system, Production and Productivity*	*Method of finding optimum Batch size. Equipment.*	*Types, Advantages and disadvantages of Incentive scheme*
S-7	SLO-1	*Motion economy principles.*	*Introduction and procedure on Assembly and line balancing*	*Definition of production and function*	*ABC analysis.*	*Productivity base incentives*
S-8	SLO-1	*Charging Techniques*	*Material Handling, scope and importance. Types of material handling systems.*	*Type of production systems*	*Introduction to Value Engineering and its importance, Case studies*	*Case Example of Evaluation of incentive scheme*
S-9	SLO-1	*SIMO chart, Ergonomics and Industrial design.*	*Methods of material handling*	*Definition of productivity and productivity measurement.*	*Types of cost-Cost of production and Labour cost-Simple problems*	*Importance of Environmental pollution and control*

Learning Resources	1. *SC Sharma, TR Banga "Industrial Engineering and Management", Khanna Publications Pvt,2017* 2. *Khanna.O.P, "Industrial Engineering and Management", Dhanpat Rai Publications Pvt Ltd, 2014* 3. *Buffa E.S,"Modern Production / Operational Management", John Wiley & Sons, 2013* 4. *Samuel Eilon, "Elements of Production Planning and Control", McMillan and Co., Digitized, 2012*	5. *Kumar.B, "Industrial Engineering and Management", 9th edition, Khanna Publishers, New Delhi, 2009* 6. *James M. Apple, "Principles of Layout and Material Handling", Ronald press,2012* 7. *Maynard.H, "Industrial Engineering Hand Book", McGraw Hill Book Co. NewYork, 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
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2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr. Vimal KEK, National Institute of Technology, Patna, vimalkek@nitp.ac.in*	*2. Thirugnanam. A, SRMIST*

Course Code	18MEO112T	Course Name	PRODUCTION MANAGEMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the principles of Production Management*
CLR-2 :	*Acquire knowledge on Inventory Management and Work study*
CLR-3 :	*Be familiar with the Job evaluation and Scheduling*
CLR-4 :	*Be familiar with the Plan and execute of the Project*
CLR-5 :	*Attain the knowledge about Implementation and Quality Assurance in Management*
CLR-6 :	*Be familiar with the basic aspects of Production Management like Inventory Management, Work study, Job evaluation, Scheduling, project management, MRP and TQM.*

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 production management and to recognize the relationship with other functional areas and acquire the knowledge about capacity, location and layout planning.*	*1 & 2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	*M*	-	-	-	-	-	*M*	
CLO-2 :	*Acquire knowledge on Inventory management and Work study*	*1*	*90*	*85*	*H*	*M*	-	-	-	-	-	-		-	-	-	-	-	*M*	
CLO-3 :	*Appreciate the Job evaluation and understand the need of scheduling*	*1*	*90*	*85*	*H*		-	-	-	-	-	-	*M*	-	-	-	-	-	*M*	
CLO-4 :	*Understand the theory behind the Project management and acquire the knowledge about MRP, ERP and Supply chain management.*	*1 & 2*	*90*	*85*	*H*	*M*	-	-	-	-	-	-		-	-	-	-	-	*M*	
CLO-5 :	*Obtain the knowledge about Total Quality Management*	*1 & 2*	*90*	*85*	*H*		-	-	-	-	-	-	*M*	-	-	-	-	-	*M*	
CLO-6 :	*Recognize the use of production management, acquire knowledge on the inventory management and work study, job evaluation and scheduling, study the total quality management on production process.*	*1*	*90*	*85*	*H*	*M*	-	-	-	-	-	-	*M*	-	-	-	-	-	*M*	

		Introduction to Production Management	Inventory Management and Work Study	Job Evaluation and Scheduling	Project Management and MRP	Total Quality Management
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History and development of production management*	*Inventory Control and cost, procurement and purchasing methods*	*Job evaluation: objectives, methods and factors affecting wage structure.*	*Project Management Phases and Project Appraisal*	*Quality management systems and Factors controlling quality*
S-2	SLO-1	*Functions and scope of different types of production processes*	*Warehousing Procedure and records in stock control, stores management*	*Types of wages, methods of wage system and characteristics*	*PERT and CPM*	*Impact of poor quality, challenges and Quality cost*
S-3	SLO-1	*Relationship of production management with other functional areas*	*Method Study and Means of increasing productivity*	*Value analysis and value engineering*	*Material requirement Planning (MRP)*	*Quality Assurance and Quality Circle*
S-4	SLO-1	*Capacity planning and its types*	*Charts and diagrams used in method study*	*Aggregate planning and strategies*	*Manufacturing resources Planning (MRP II)*	*Statistical Process Control and Control Charts with examples*
S-5	SLO-1	*Capacity decisions and their importance, Capacity planning strategies: types*	*Role of work study and human factors in work study*	*Forecasting and its methods*	*Enterprise Resource Planning (ERP)*	*Total Quality Management*
S-6	SLO-1	*Rooting, Techniques of rooting*	*Objectives and basic procedure for work study*	*MPS and Scheduling, Related Problems*	*Logistics: types and strategies*	*Just in Time with Case Study*
S-7	SLO-1	*Location planning: factors, types of planning, location models*	*Factors affecting work study*	*Scheduling principles, inputs, strategies, sequence and Assumptions, Case study*	*Supply chain Management*	*Six Sigma*
S-8	SLO-1	*Layout planning: factors and types*	*work measurement, objectives and techniques of work measurement*	*Gantt chart and Johnson's algorithm*	*Objectives and Decision Phases of Supply chain Management*	*Maintenance management and its types*
S-9	SLO-1	*Productivity management: definition, productivity index*	*Problems in Inventory control & work study*	*Problems in Gantt chart and Johnson's algorithms*	*Roles and Development in Supply chain Management*	*Effects of maintenance, Reliability and Replacement Techniques*

Learning Resources	1. *S.K. HajraChoudhury et al, "Production Management", MP publishers, New Delhi, 1990.* 2. *Heizer.,"Operations Management", Pearson, New Delhi, 2016.* 3. *Ahuja, K.K., "Production Management", CBS Publishers, New Delhi, 2013.* 4. *Agarwal and Jain, "Production Management", Khanna publishers, New Delhi, 1998*	5. *S N.Chary, "Production and operation management", Tata Mcgraw Hill publications, New Delhi, 2009* 6. *Goel, B.S., "Production Management", Pragathi&prakasan publishers, Mererut, 1984.* 7. *S.Anil and N.Suresh, "Production and operation Management", New Age International publishers, New Delhi, 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. S.Bhargav, GM,Rane Brake, Trichy	*1. Dr. V.Srinivasan,Annamalai University, srinivraghavan@yahoo.com*	*1. Mr.T.Geethapriyan, SRMIST*
2. Dr. Muthumanikkam, Jt. Director, CVRDE, DRDO,Avadi,Chennai.	*2.Dr.Assaithambi, Govt. Col. of. Engg, sengipatti,Thanjavur, basaithambi@gcetj.edu.in*	*2. Dr.A.Arul Jeya Kumar, SRMIST*

Course Code	18MEO113T	Course Name	DESIGN OF EXPERIMENTS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Statistical data books		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with necessity, fundamentals and potential practical problemsin design of experiments*
CLR-2 :	*Be familiar with methodology used for design of experiments*
CLR-3 :	*Be familiar with robust design concepts with case studies*
CLR-4 :	*Be familiar with the concept of response surface design*
CLR-5 :	*Be familiar with the concepts of confounding and analysis of variance (ANOVA)*
CLR-6 :	*Be familiar with how the analysis of the data from the experiment should be carried out.*

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 basics and potential practical problems in design of experiments*	*1, 2*	*90*	*85*	*H*	*H*	*H*	*H*	*L*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*H*
CLO-2 :	*Understand and apply various methodology for design of experiment to evaluate case studies*	*1, 2 & 3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*H*
CLO-3 :	*Apply the concept of robust design to evaluate case studies*	*1, 2 & 3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*H*
CLO-4 :	*Expose the concepts of response surface design to evaluate experimental problems*	*1, 2 & 3*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*H*
CLO-5 :	*Apply the concept of confounding and ANOVA to evaluate case studies*	*1, 2 & 3*	*90*	*85*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*H*
CLO-6 :	*Construct optimal or good designs for a range of practical experiments and describe how the analysis of the data from the experiment should be carried out*	*1, 2 & 3*	*90*	*85*	*H*	*H*	*H*	*H*	*H*	*M*	*M*	*L*	*L*	*L*	*M*	*M*	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction in Design of experiments (DOE)*	*Need for DOE methodology*	*Introduction to Robust design, Loss functions*	*Background of response surface design*	*Introduction and uses of confounding*
S-2	SLO-1	*The fundamental and potential practical problems in experimentation*	*Barriers in the successful application of DOE*	*Eight steps in Taguchi methodology*	*Multiple Responses and Contour profile of response surface plot*	*2^3 factorial experiment with complete confounding*
S-3	SLO-1	*Statistical thinking and its role within DOE*	*Practical methodology of DOE and Analytical tools for DOE*	*Orthogonal array, Selecting the interaction, Linear graphs*	*Creation of response surface designs*	*2^3 factorial experiment with partial confounding*
S-4	SLO-1	*Basic principles of DOE and Degrees of freedom*	*The confidence interval for the mean response*	*S/N ratio: Larger-the-better, Smaller-the-better, Nominal-the-best*	*Central composite designs (Rotatable central composite design)*	*Confounding in the 2^n series and examples*
S-5	SLO-1	*Selection of quality characteristics for experiments*	*Introduction to Screening design*	*Analyze the data, factor effect diagram*	*Central composite designs (Rotatable central composite design)*	*Confounding of 3^n factorial and examples*
S-6	SLO-1	*Understanding key interaction in processes*	*Geometric and non-geometric P-B design*	*Levels of parameters*	*Box-Behnken design with case studies*	*ANOVA (One-way and two-way, higher-way ANOVA)*
S-7	SLO-1	*An alternative method for calculating two-order interaction effect*	*Introduction of full factorial design, Basic concepts of 2^2, 2^3 and 2^k designs*	*Confirmation test*	*Random factor models and its industrial application , Random Effects Models*	*MANOVA and ANCOVA overview*
S-8	SLO-1	*Synergistic interaction, Antagonistic interaction*	*Solving Case studies on Full factorial design with statistics software*	*Augmented design with simple case studies*	*Two Factor Factorial with Random Factors*	*Solving Case studies on ANOVA with statistics software*
S-9	SLO-1	*Synergistic interaction versus Antagonistic interaction*	*Solving Case studies on Full factorial design with statistics software*	*Solving case studies on robust design with statistics software*	*Two Factor Mixed Models with random factors*	*Regression Models and Regression Analysis*

Learning Resources	1. *Douglas C Montgomery, " Design and Analysis of Experiments" , Eighth Edition, John Wiley & Sons Ltd., 2012* 2. *Box, G.E.P. and Draper N.R, "Empirical Model-Building and Response Surfaces", John Wiley &sons 2007.* 3. *Jijuantony, "Design of Experiments for Engineers and Scientists", Second Edition, Elsevier, 2014.* 4. *M N Das, N C Giri, "Design and Analysis of Experiments", New Age International (P) Limited, Publishers, 2003.*	5. *Russell R. Barton, "Graphical Methods for the Design of Experiments", Springer, 2012.* 6. *Larry B. Barrentine, "An introduction to Design of Experiments A simplified approach", New Age International Publishers, 2014.* 7. *William G. Cochran, Gertrude M. Cox, "Experimental Design", John Wiley and sons, Inc, 2003.* 8. *Myres R.H, Montgomery D. C, Anderson-Cook C. M "Response Surface Methodology", Wiley, 2016.* 9. *Cox D.R, Reid N, "The theory of Design of Experiments", Chapman and Hall, CRC Press, 2000.* 10. *John, P.W.M, "Statistical Design and Analysis of Experiments", Society for Industrial and Applied Mathematics, 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	*25%*	-	*20 %*	-	*20 %*	-	*20%*	-	*20 %*	-
	Understand										
Level 2	Apply	*50 %*	-	*60 %*	-	*50 %*	-	*50%*	-	*60 %*	-
	Analyze										
Level 3	Evaluate	*25 %*		*20 %*		*30 %*	-	*30%*	-	*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
Dr.R.Kalimuthu, ISRO, Mahendragiri	*Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*Dr. S. Murali, SRMIST*
Dr.A.Velayutham, DRDO, Avadi	*Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*Dr. S. Prabhu, SRMIST*

Course Code	18MEO114T	Course Name	MODERN CONTROL THEORY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards		Statistical data books	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand and remember the fundamentals of modern control theory including basic controller actions*
CLR-2 :	*Create mathematical models for dynamic systems and Apply transfer function and state space models*
CLR-3 :	*Upon learning the students shall Analyze the transient and steady state system response of control systems*
CLR-4 :	*Upon learning the students shall Analyze the stability of control system by different methods*
CLR-5 :	*Upon learning the students shall Analyze multiple input multiple output systems using state space approach*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning: Level of Thinking (Bloom)	Learning: Expected Proficiency (%)	Learning: Expected Attainment (%)
CLO-1 :	*understand basic terminologies, concepts of feedback, dynamic system modeling using linear differential equations, applytransfer functions for control system*	*1,2*	*90*	*85*
CLO-2 :	*Understand modeling in state space, apply state space model and evaluate different mechanical systems*	*1,2*	*85*	*80*
CLO-3 :	*understandstandard test signals, apply and evaluate system response for first and second order systems*	*1,2,3*	*85*	*80*
CLO-4 :	*understand, apply, and create optimal control systems based on stability analysis by different approaches*	*1,2,3*	*85*	*80*
CLO-5 :	Analyze the multiple input multiple output dynamic systems based on state space approach, apply Kalman and Gilbert test	1,2,3	90	85

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

		Introduction to control systems	System Modeling	System response	Stability Analysis	State space analysis of MIMO systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Brief Review, Basic terminologies and examples, Classical-Modern-Robust-Automatic control systems, Concepts of Feedback: Closed-loop and open-loop control systems, Design and compensation of control systems (Design procedure)*	*Modeling in state space: State, State variables, State vector, State space, State equations for a MIMO system*	*Transient and steady state response, Standard test signals- Mathematical expressions- type and order of a system*	*Complex s-plane, Routh's stability criterion*	*MIMO System analysis: state-space approach*
S-2	SLO-1	*Brief Review, Basic terminologies and examples, Classical-Modern-Robust-Automatic control systems, Concepts of Feedback: Closed-loop and open-loop control systems, Design and compensation of control systems (Design procedure)*	*Modeling in state space: State, State variables, State vector, State space, State equations for a MIMO system*	*First order Systems: Unit step response and Unit ramp response, Concepts of time constant and its importance in speed of response*	*Complex s-plane, Routh's stability criterion*	*MIMO System analysis: state-space approach*
S-3	SLO-1	*Modeling of control systems using linear differential equations, Transfer function expressions (with note on convolution integral), Block diagrams*	*State space representation of dynamic systems – nth order systems of linear differential equations, State space models for mechanical systems: Examples from mechanical, electrical, liquid-level, thermal systems*	*First order Systems: Unit step response and Unit ramp response, Concepts of time constant and its importance in speed of response*	*Analysis of control systems by Root-Locus method: concepts and procedure, Design of Lead-Lag compensation based on Root-Locus approach*	*State space representation in controllable, observable, diagonal and jordan canonical forms, order reduction and solution of state equations*
S-4	SLO-1	*Modeling of control systems using linear differential equations, Transfer function expressions (with note on convolution integral), Block diagrams*	*State space representation of dynamic systems – nth order systems of linear differential equations, State space models for mechanical systems: Examples from mechanical, electrical, liquid-level, thermal systems*	*Second order systems: Servo system and Servo system with velocity feedback*	*Analysis of control systems by Root-Locus method: concepts and procedure, Design of Lead-Lag compensation based on Root-Locus approach*	*State space representation in controllable, observable, diagonal and jordan canonical forms, order reduction and solution of state equations*

S-5	SLO-1	*Basic Control action: Types of controllers, Principles of pneumatic, hydraulic and electronic controllers*	*State space representation of dynamic systems – nth order systems of linear differential equations, State space models for mechanical systems: Examples from mechanical, electrical, liquid-level, thermal systems*	*Second order systems: Servo system and Servo system with velocity feedback*	*Analysis of control systems by Root-Locus method: concepts and procedure, Design of Lead-Lag compensation based on Root-Locus approach*	*Controllability and observability, Kalman and Gilbert test*
S-6	SLO-1	*Basic Control action: Types of controllers, Principles of pneumatic, hydraulic and electronic controllers*	*State space representation of dynamic systems – nth order systems of linear differential equations, State space models for mechanical systems: Examples from mechanical, electrical, liquid-level, thermal systems*	*Second order systems: Servo system and Servo system with velocity feedback*	*Stability: Polar, Bode and Nyquistplots*	*Controllability and observability, Kalman and Gilbert test*
S-7	SLO-1	*Basic Control action: Types of controllers, Principles of pneumatic, hydraulic and electronic controllers*	*State space representation of transfer function systems*	*Controller errors, Higher order systems, Effects of proportional-integral-derivative control actions on the system response*	*Stability: Polar, Bode and Nyquistplots*	*Pole placement approach to the design of control systems, State observers, Design of servo systems*
S-8	SLO-1	*Tuning of PID controller: Ziegler-Nichols rules*	*State space representation of transfer function systems*	*Controller errors, Higher order systems, Effects of proportional-integral-derivative control actions on the system response*	*Lead-Lag compensation based on frequency response approach*	*Pole placement approach to the design of control systems, State observers, Design of servo systems*
S-9	SLO-1	*Tuning of PID controller: Ziegler-Nichols rules*	*Linearisation of a non-linear system*	*Controller errors, Higher order systems, Effects of proportional-integral-derivative control actions on the system response*	*Lead-Lag compensation based on frequency response approach*	*Pole placement approach to the design of control systems, State observers, Design of servo systems*

Learning Resources	*1. K. Ogata - 'Modern Control Engineering - Prentice Hall (India) - Pearson Education - 2009 - 5th Edition* *2. Francis. H. Raven - 'Automatic Control Systems' – McGraw Hill - 1995 - 5th Edition*	*1. B. C. Kuo - 'Automatic Control Systems' - Wiley - 2009 - 9th Edition* *2. Schaum's Series - 'Feedback and Control Systems' – McGraw Hill Education - 2013 - 2nd Edition* *3. I. J. Nagarath& M. Gopal - 'Control Systems' - New age International Publishers.* *4. Norman Nise- 'Control Systems Engineering' - Wiley and Sons - 2015 - 7thEdition* *5. Rihard C. Drof and Robert. H. Bishop Addison - 'Modern Control Systems' – Wesley – 2010 - 12th Edition*

Learning Assessment						
	Level of Thinking	Continuous Learning Assessment (50%)				Final Examination (50%)
		CLA – 1 (10%)	CLA – 2 (15%)	CLA – 3 (15%)	CLA – 4 (10%) #	
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
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2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.R.Prabhusekar, rprabhusekar@mnnit.ac.in, MNNIT Allahabad*	*Dr. P. Nandakumar, SRMIST*

Course Code	18MEO115T	Course Name	FACILITIES PLANNING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the purpose of facilities planning process*
CLR-2 :	*Acquire knowledge on requirements and relationships of facilities planning*
CLR-3 :	*Be familiar with the facility design*
CLR-4 :	*Acquire knowledge on strategies adopted for designing a facility*
CLR-5 :	*Attain the knowledge about material handling and facility layout design*
CLR-6 :	*Be familiar with the basic aspects of evaluating, selecting maintaining in facilities planning and Industrial Acts and safety*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the basic concepts in facilities planning process*	*1&2*	*90*	*85*	*H*					*M*						*L*			
CLO-2 :	*Acquire knowledge on requirements and relationships of facilities planning*	*1*	*90*	*85*	*M*														
CLO-3 :	*Understand facility design for various functions and acquire knowledge about strategies adopted for designing a facility*	*1*	*90*	*85*	*H*		*H*	*M*										*L*	
CLO-4 :	*Acquire knowledge on material handling and facility layout design*	*1&2*	*90*	*85*	*H*		*H*	*M*		*M*						*L*		*L*	
CLO-5 :	*Recognize the basic aspects of evaluating, selecting and maintaining in facilities planning*	*1&2*	*90*	*85*	*M*			*M*		*M*									
CLO-6 :	*Evaluate the existing facility, modify to meet the requirements and understand Industrial Acts and safety.*	*1*	*90*	*85*	*M*					*M*						*M*			

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition, Significance and objectives of facilities planning*	*Department planning*	*Material Handling, Principles and classification*	*Facility design for various functions*	*Introduction to Facilities plan Evaluating. Facilities plan evaluation procedure, Factors to evaluate facility planning*
S-2	SLO-1	*Facilities planning process*	*Activity relationship*	*Designing material handling systems, Estimating material handling costs, Safety consideration*	*Warehouse operation and location problems*	*Qualitative Evaluation Techniques*
S-3	SLO-1	*Strategic Facilities Planning*	*Flow patterns*	*Layout Planning Models and Basic layout types*	*Nature of Location Decision, Need for facility location planning*	*Efficiency indices, Cost of Evaluation of Layout*
S-4	SLO-1	*Developing facilities planning strategies*	*Planning and measuring*	*Layout procedures, Algorithmic approaches and Pair-wise exchange method*	*General procedures and actors influencing location decisions, Facility Location Models*	*Facilities plan selection, Steps and involved in Facilities plan selection*
S-5	SLO-1	*Nature of Location Decision, Need for facility location planning*	*Space requirements*	*graph based approaches blocplan, logic, multiple approach*	*Economics and cost analysis, Rural and urban location pattern*	*Facility plan preparing, Importance of facility preparing*
S-6	SLO-1	*General procedures and Factors influencing location decisions, Facility Location Models*	*Personnel requirements*	*Multi floor facility layout, Developing layout alternatives*	*Manufacturing systems and Services*	*Facilities plan implementing and facility plan maintaining*
S-7	SLO-1	*Influence of product*	*Employee, facility interface, Multi-facility location problem, Euclidean-distance location problem, Minimax location probem.*	*Computer assisted layout planning*	*Fixed automation system and Flexible manufacturing system*	*Necessity of Industrial acts, The Indian Factories Act 1948, The industrial Dispute act1947, The minimum Wage Act 1948.*
S-8	SLO-1	*Process and schedule design*	*Restrooms, food services, health services*	*ALDEP, CORE LAP, CRAFT , PLANET , MAT*	*Reduction in work in process, Just-in-time manufacturing*	*Introduction to Industrial safety, Investigation and analysis of accidents, Safety devices Causes and sources of accidents.*
S-9	SLO-1	*Facilities design and procedure*	*Office facility planning*	*Commercial facility layout packages*	*Facilities planning trends*	*Safety devices, Causes and sources of*

						accidents.

Learning Resources	1. *Tompkins.J.A, White.J.A, Bozer.Y.A, and Tan Choco.J.M.A, "Facilities Planning", 4th Edition, John Wiley & sons, India, 2010.* 2. *James M. Apple, "Principles of layout and material handling", Ronald press, 1977.* 3. *Francis.R.L, McGinnis.L.F, and White J.A, "Facility Layout and Location: An analytical approach", Prentice Hall, New Jersey, 1992.*	4. *Gupta and Patel, "Work study", Khanna Publishers, New Delhi.* 5. *Kanna.O.P, "Industrial Engineering and management", Khanna Publishers,New Delhi , 2018* 6. *Sharma SC & Banga TR, "Industrial Engineering & Management", Khanna Publishers ,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
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2. Mr. S.Arun kumar, Executive Engineer, ONGC borntough18@gmail.com	*Dr. K.E.K Vimal , Assistant Professor, NIT, Patna*	*Dr. S.Murali*

Course Code	18MEO116T	Course Name	INDUSTRIAL SAFETY AND ENVIRONMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the safety issues in design, handling and industrial environment*
CLR-2 :	*Be familiar with the accident prevention and motivating factors of safety suggestion schemes*
CLR-3 :	*Know the various safety measures followed in material handling system*
CLR-4 :	*Be familiar with the safety measures followed in chemical industries and chemical laboratories*
CLR-5 :	*Be familiar with the environmental impact Assessment*
CLR-6 :	*Be familiar with the regulations for health, safety and environment*

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 :	*Conduct basic safety inspections using strategies that they have developed*	*1&2*	*90*	*85*
CLO-2 :	*Understand the motivating factors of safety suggestion schemes, thereby preventing accidents*	*1*	*90*	*85*
CLO-3 :	*Understand the various safety measures to be followed in material handling system*	*1&2*	*90*	*85*
CLO-4 :	*Understand the various safety measures followed in chemical industries and chemical laboratories*	*1&2*	*90*	*85*
CLO-5 :	*Gain knowledge in basic environmental impact Assessment*	*1&2*	*90*	*85*
CLO-6 :	*Create a document addressing the principles for developing and implementing a successful occupational health and safety program and evaluation of a work site*	*1&2*	*90*	*85*

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
L		*H*		*H*	*M*	*H*	*L*	*H*	*M*	*L*	*H*			
H	*M*	*H*		*H*	*M*	*H*	*L*	*H*	*H*	*M*	*H*			
H	*L*	*H*		*H*	*L*	*H*	*L*	*M*	*H*		*H*			
H	*L*	*H*		*H*	*L*	*H*	*L*	*M*	*H*		*H*			
L		*H*		*M*		*H*		*M*			*H*			
H	*M*	*H*		*H*	*M*	*H*	*L*	*H*	*H*	*M*	*H*			

		Accident Prevention	Safety in Material Handling	Safety in Chemical Industries	Environmental Impact Assessment	Regulations for Health, Safety and Environment
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definitions and theories of accident, reportable and non-reportable accidents, unsafe act,unsafe condition and dangerous occurrence*	*General safety consideration in material handling*	*Safety in the design process of chemical plants*	*Evolution, Concepts, Methodologies, Screening, Scoping and Checklist of EIA*	*Factories act and rules, Workmen compensation act*
S-2	SLO-1	*Theories and principles of accident causation*	*Ropes, Chains, Sling, Hoops, Clamps*	*Safety in operational and maintenance of chemical plants*	*Rapid and Comprehensive EIA*	*Indian explosive act*
S-3	SLO-1	*Cost of accidents, Accident reporting and investigations, accident reports- Class exercise with case study.*	*Arresting gears and Prime movers*	*Exposure of personnel*	*Legislative and environmental clearance procedure in India*	*Gas cylinder rules*
S-4	SLO-1	*Safety committees and their need, types and advantages*	*Ergonomic consideration in material handling*	*Operational activities and hazards*	*Prediction tools for EIA*	*Environmental pollution act*
S-5	SLO-1	*Safety education and training and their importance*	*Design, installation, operation andmaintenance of Conveying equipment.*	*Safety in storage and handling of chemicals and gases*	*Assessment of Impact of air, water and soil*	*Indian petroleum act and rules*
S-6	SLO-1	*Various training methods*	*Hoisting, traveling and slewing mechanisms*	*Hazards during transportation and Pipeline transport*	*Assessment of Impact of noise, biological and Socio cultural environment*	*Oil industry safety directorate (OISD)*
S-7	SLO-1	*Accident prevention and Motivating factors of safety suggestion schemes*	*Selection, operation and maintenance of industrial trucks*	*Safety in chemical laboratories*	*Public participation*	*Indian Electricity act and rules*
S-8	SLO-1	*Safety performance*	*Selection, operation and maintenance of Mobile cranes and Tower crane*	*Specific safety consideration for cement, paper and pharmaceutical*	*Resettlement and Rehabilitation*	*Mines act and rules, Manufacture, Storage and Import of Hazardous Chemical rules 1989*
S-9	SLO-1	*Definitions connected with measuring safety performance as per Indian and International standards*	*Storage and Retrieval of common goods of various shapes and sizes in a general store of a big industry.*	*Specific safety consideration for petroleum, petro -chemical, rubber, fertilizer and distilleries*	*Documentation of EIA*	*Indian motor vehicles act and rules*

Learning Resources	1. *Thomas J.Anton, "Occupational safety and health management", (2nd Edition). New York, McGraw Hill1989.* 2. *Rieske, David W., Asfahl and C. Ray, "Industrial Safety and Health Management", 6th Edition, Prentice Hall Professional Technical Ref. 2009.* 3. *Heinrich.H.W, "Industrial Accident Prevention", McGraw-Hill, 1980.* 4. *Alexandrov.M.P,"Material Handling Equipment",Mir Publishers, Moscow, 1981.* 5. *Lees.F.P, Loss "Prevention in Process Industries", Butterworths, NewDelhi, 1986.*	6. *Handlin.W, "Industrial Hand Book", McGraw-Hill, 2000.* 7. *Canter.R.L, "Environmental Impact Assessment", (2nd Edition), McGraw Hill, 1996.* 8. *IS CODES: IS 5903, IS 807, IS 2760, IS 14469, IS 13367-1, IS 5324, IS 7167, IS 7155, IS 1800.1, IS 3521 of Oil Industry Safety Directorate, Govt. of India.* 9. *The manufacture, storage and import of hazardous chemical rules 1989, Madras BookAgency, Chennai.*

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.Bhargav, GM,Rane Brake, Trichy	*1. Dr. R. Raju, Anna university, Chennai.*	*1. Mr. A. C. Arun Raj, SRMIST*
2. Dr. Muthumanikkam, Jt. Director, CVRDE, DRDO,Avadi,Chennai.	*2. Dr. T. Paul Robert, Anna university, Chennai.*	*2. Mr. A. Thirugnanam, SRMIST*

Course Code	18MEO117T	Course Name	ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS	Course Category	O	Open elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the basic concepts of artificial intelligence*
CLR-2 :	*Be familiar with various search techniques used in artificial intelligence*
CLR-3 :	*Be familiar with various Matching techniques used in artificial intelligence*
CLR-4 :	*Be familiar with the concept of knowledge management*
CLR-5 :	*Be familiar with the programming language*
CLR-6 :	*Be familiar with basic concepts of expert system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 (Level of Thinking (Bloom))	Learning 2 (Expected Proficiency (%))	Learning 3 (Expected Attainment (%))
CLO-1 :	*Understand the basic concepts of artificial intelligence*	*1&2*	*90*	*85*
CLO-2 :	*Identify and use various search techniques*	*1&2*	*90*	*85*
CLO-3 :	*Understand the concept of matching techniques*	*1&2*	*90*	*85*
CLO-4 :	*Gain knowledge on the concept of knowledge management*	*1&2*	*90*	*85*
CLO-5 :	*Do coding in python language*	*1*	*90*	*85*
CLO-6 :	*Understand basic concepts of expert system*	*1&2*	*90*	*85*

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

		Introduction To Ai	Problem Solving Agents	Knowledge Organisation, Communication	Programming Language	Expert Systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History, Definition of AI*	*Problem Definition, formulating problems and Searching for solutions*	*Knowledge organization, manipulation and knowledge acquisition*	*Introduction to python its syntax*	*Introduction to Expert Systems*
S-2	SLO-1	*Emulation of human cognitive process*	*Measuring problem, solving performance with examples*	*Indexing and Retrieval techniques*	*Input, output statements*	*Basic Activities of an expert system*
S-3	SLO-1	*Semantic nets*	*Search /Strategies: Uninformed or Blinded search Breadth first search.*	*Integration of knowledge in memory organization systems*	*Numeric functions*	*Interpretation, Prediction and Diagnosis*
S-4	SLO-1	*An abstract view of modeling*	*Uniform cost search: Depth first search, Depth limited search*	*Matching Techniques: Need for matching and Matching problem*	*Input statements for declaration of variables, Output statements for declaration of variables*	*Design, Planning and Monitoring*
S-5	SLO-1	*Elementary knowledge*	*Iterative deepening, Depth first search and Bi-directional search*	*Partial matching, Fuzzy matching and RETE matching algorithm*		*Debugging, Repair, Instruction and Control*
S-6	SLO-1	*Computational logic*	*Comparing uniformed search strategies and Informed search strategies*	*Natural language processing: Overview of linguistics*	*Interaction functions*	*Basic aspect of expert system*
S-7	SLO-1	*Analysis of compound statements using simple logic connectives*	*Heuristic information and Hill climbing methods*	*Basic semantic analysis and Representation structures*	*recursion functions*	*Acquisition module frames of expert systems, Knowledge base*
S-8	SLO-1	*Predicate logic*	*Best First Search; Greedy Best First Search, Branch-and- Bound Search*	*Natural language generation.*	*Property list and arrays*	*Production rules , Semantic net and Inference engine*
S-9	SLO-1	Simple exercises	Optimal search and A* algorithm and iterative deepening A*	Bayesian Networks and Bayesian Inference		Backward chaining and forward chaining

Learning Resources	
	1.Schalkoff, R.J., "Artificial Intelligence: An Engineering Approach", McGraw-Hill, 1990
	2. Elaine Rich and Kelvin Knight, "Artificial Intelligence", Tata McGraw Hill, New Delhi, 2009
	3. Russell , " Artificial intelligence :A modern Approach , Pearson Education ,3rd edition,2013
	4. Donald A. Waterman, "A Guide to Expert Systems", Addison-Wesley Longman Publishing Co., Inc. Boston, MA, USA ©1985 ISBN:0-201-08313-2
	5. Nils J. Nilsson,"Principles of Artificial Intelligence", Narosa Publishing House, 2000.
	6. Eugene Charniak and Drew McDermot, "Introduction to Artificial Intelligence", Addison Wesley Longman Inc., 1998
	7. Patterson, "Introduction to Artificial Intelligence and Expert systems", Prentice Hall of India, New Delhi, 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
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2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	*2. Mrs Deborah Stephan*

Course Code	18MEO118T	Course Name	MICROCONTROLLER AND ITS APPLICATIONS IN ROBOTICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire the fundamental concepts of microcontroller.*
CLR-2 :	*Learn to program the microcontroller using assembly language.*
CLR-3 :	*To expose interfacing of microcontroller with the external world using a high level language.*
CLR-4 :	*To introduce students to an open source microcontroller and its programming.*
CLR-5 :	*To enable students with the Design of Microcontroller based circuits based on applications on robotics.*
CLR-6 :	*Impart the Knowledge about the concepts and selection of microcontroller to its 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 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 fundamental concepts of microcontroller.*	*1*	*90*	*85*	*M*	-	*M*	-	-	-	-	-	-	-	-	-	*L*	*L*	*L*
CLO-2 :	*Program the microcontroller using assembly language.*	*1*	*90*	*85*	*H*	*M*	*M*	*L*	*L*	-	-	-	-	-	-	-	*H*	*H*	*L*
CLO-3 :	*Interface I/O modules with microcontroller from external world.*	*1*	*90*	*85*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*M*	*L*
CLO-4 :	*Demonstrate a fundamental knowledge of open source microcontroller and learnt to program it.*	*2*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	-	-	-	*M*	-	-	-	*H*	*H*	*L*
CLO-5 :	*Demonstrate microcontroller based circuit for engineering applications.*	*3*	*90*	*85*	*H*	*M*	*H*	*H*	*H*	-	-	-	*H*	-	-	-	*H*	*M*	*L*
CLO-6 :	*Select suitable microcontroller to meet specific requirements.*	*3*	*90*	*85*	*H*	*M*	*H*	*M*	*L*	-	-	-	*L*	-	-	-	*H*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Data representation and Numbering system and its types are binary, decimal, hexadecimal systems*	*Introduction to Assembly language*	*Introduction to External world interfacing with microcontroller, Analog signals and Digital signals*	*Introduction to open source microcontroller*	*Application of Microcontroller in various fields*
S-2	SLO-1	*Data conversion from hexadecimal to decimal and decimal to binary, binary addition and subtraction*	*Instruction sets with syntax and examples.*	*Analog to digital conversion and its types*	*Open Hardware platform basic knowledge of its hardware and its software environments*	*Advancement in Microcontroller*
S-3	SLO-1	*Introduction and history description about microcontrollers*	*Timers and its types*	*Digital to Analog conversion and its types*	*Variables ,Digital inputs with programs*	*Study and Design a Home security system using microcontroller*
S-4	SLO-1	*Specification and Internal architecture of 8051*	*TCON,TMOD*	*Analog inputs are mechanical switches ,relays*	*Digital Outputs with programs*	*Study and Design a Elevator system*
S-5	SLO-1	*Pin description of 8051*	*Delay program with and without timer*	*Digital outputs are LED,7 segment display and LCD interfacing*	*Reading analog signals and PWM signal generation with programs*	*Study and Design a Sensor guided mobile robot using ultrasonic sensor*
S-6	SLO-1	*Various Addressing modes of 8051 are immediate, register, direct*	*Interrupts and its Types*	*DC Motor Interfacing*	*Conditional statements are if ,else and nested if with programs*	*Study and Design a Tic Tac Toe playing robot*
S-7	SLO-1	*Indirect, Relative, Indexed and Absolute addressing modes*	*Programming using Interrupts*	*Stepper Motor Interfacing*	*Looping statements are for ,while and Do while with programs*	*Study and Design a Line following robot as a maze solver using microcontroller*
S-8	SLO-1	*Difference between microcontroller with microprocessor*	*I/O Ports and its 3 modes of operation*	*Servo Motor Interfacing*	*Functions and recursive function with programs*	*Study and Design a Unmanned Aerial Vehicle using microcontroller*
S-9	SLO-1	*Selection criterion for choosing microcontroller*	*Serial communication and its modes, SCON*	*Digital inputs -Keypad and its interfacing*	*Continuous Serial monitoring and hardware interrupt with programs*	*Study and Design a Soccer playing robot using microcontroller*

Learning Resources	1. *Muhammad Ali Mazidi,"8051 Microcontroller and Embedded Systems", Pearson New International Edition, 2014.* 2. *Simon Monk, "Programming Arduino Next Steps: Going Further with Sketches", Second Edition, McGraw Hill Professional, 2018.* 3. *MacKenzie I. Scott, "The 8051 Microcontroller", Pearson Education India, 2011.*	1. *Donald Norris,"Python for Microcontrollers: Getting Started with MicroPython", McGraw Hill Professional, 2016.* 2. *Jeff Cicolani," Beginning Robotics with Raspberry Pi and Arduino: Using Python and OpenCV,Apress,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.,
SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Sreejith Balachandran, Senior Engineer,COMAU ROBOTICS	*Hushein Rasheeth, Vel Tech - Technical University*	*1. Mr.V.Manojkumar, SRMIST*
Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*Dr. P. Hariharan, Anna University, hari@annauniv.edu, hariharan2311@gmail.com*	*2. Mr.N. Karthikeyan, SRMIST*
Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.N.Arunachalam, IIT Madras, chalam@iitm.ac.in*	

Course Code	18MEO119T	Course Name	MACHINERY FAULT DIAGNOSTICS AND SIGNAL PROCESSING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the working of a machinery and need for machine maintenance*
CLR-2 :	*Be familiar with the reason for Failure and capable of doing failure analysis*
CLR-3 :	*Be familiar with the basics of Signal analysis and Machinery condition monitoring*
CLR-4 :	*Be familiar with Instrumentation systems*
CLR-5 :	*Be capable of Machine Testing and Analysis*
CLR-6 :	*Be familiar of industrial practices in machine troubleshooting*

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 knowledge on basic components and working of a machine*	*1& 2*	*90*	*85*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-	-
CLO-2 :	*Appreciate the process of monitoring the conditions of a machine*	*1*	*90*	*85*	*H*	-	*H*	-	*H*	-	-	-	*M*	-	-	-	-	*H*	*H*
CLO-3 :	*Understand the techniques in wear and debris analysis, vibration analysis and signal analysis*	*1*	*90*	*85*	*H*	*M*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	*H*	*H*
CLO-4 :	*Understand the various tools used for monitoring the condition of machine*	*1&2*	*90*	*85*	*H*	-	*H*	-	*H*	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Understand the process of thermography and non- destructive techniques*	*1&2*	*90*	*85*	*H*	-	-	-	*M*	-	-	-	-	-	-	-	*H*	-	*H*
CLO-6 :	*Acquire skills in fault finding and diagnosis*	*1&2*	*90*	*85*	*H*	*M*	-	*M*	-	-	-	-	*H*	-	-	*H*	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Failures and failure analysis*	*Principles of Maintenance*	*Time Domain Signal Analysis*	*Data Recording and Transmission*	*Fans, Blowers, Compressors, Pumps and Turbines*
S-2	SLO-1	*Failure concepts and characteristics*	*Failure Modes Effects*	*Frequency Domain Signal Analysis*	*Vibration Transducers, Vibration Monitoring*	*Contaminant Analysis, Oil Analysis*
S-3	SLO-2	*Fault detection sensors*	*Criticality Analysis*	*Computer Aided Data Acquisition - Basics*	*Basics of Noise and Noise Monitoring*	*Fault Detection in Motors and Transformers*
S-4	SLO-1	*Data processing*	*Fault Diagnostics*	*FFT Analysis*	*Numerical problems in Noise Vibration*	*Motor Current Signature Analysis*
S-5	SLO-1	*signal analysis*	*Fault Prognostics*	*Modulation and Sidebands*	*Numerical problems in Data Acquisition*	*wear and debris Analysis*
S-6	SLO-1	*Condition based maintenance principles*	*Basics of Machinery Vibration*	*Envelope Analysis*	*Unbalance Detection, Field Balancing*	*Thermography and Ultrasonics*
S-7	SLO-2	*Fault analysis planning and system availability*	*Engineering Applications of Vibration*	*Cepstrum Analysis*	*Misalignment Detection, Cracked Shaft Detection*	*Acoustic Emission and Eddy Current Testing*
S-8	SLO-2	*Reliability/failure concepts*	*Rotor dynamics*	*Order Analysis*	*Looseness and Rub Detection, Ball and Journal Bearings*	*Radiography,Dye Penetrant Test, Visual Inspection*
S-9	SLO-1	*Application of diagnostic maintenance to specific industrial machinery and plants*	*Fault findings in rotor machines*	*Examples on signal processing in MATLAB*	*Gear Fault Detection*	*Case studies on failure and fault detection*

Learning Resources	
	1. A. R. Mohanty , "Machinery Condition Monitoring: Principles and Practices" , CRC Press, 2014. *2. William T. Thomson, Chandramouli Padmnabhan," Theory of Vibration with Applications", Pearson, V edition, 2008.* *3. PareshGirdhar, Cornelius Scheffer, "Practical machinery vibration analysis and predictive maintenance", Elsevier, 2004.*
	4. J Prasad, C G K Nair, "Non-Destructive Testing and Evaluation of Materials", Tata McGraw Hill, Education Private Limited, 2011 *5. S.S. Rao, "Vibration of Continuous systems", Wiley, 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.,
SLO – Session Learning Outcome

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Senthil Kumar. K, Divisional Manager, Global Bus – Operations, Ashok Leyland Ltd senthilkumar.k3@ashokleyland.com	*1. Dr.A.R. Mohanty, Professor, IIT Kharagpur amohanty@mech.iitkgp.ac.in*	*1. Mr.M, Dhanasekaran, SRMIST*
2. Mr.Sumit Bose, Zonal Manager, Man Trucks and Buses, smtbs69@rediffmail.com	*2. Prof. N. Ramesh Babu, IIT Madras, nrbabu@iitm.ac.in*	*2. Mr.V. Manoj Kumar, SRMIST*

Course Code	18MEO120T	Course Name	DIGITAL IMAGE PROCESSING AND MACHINE VISION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Be familiar with the sensors and Image acquisition system*
CLR-2 :	*Be familiar with the basics of image processing in Frequency domain*
CLR-3 :	*Be familiar with the image enhancement and compression*
CLR-4 :	*Know the existing vision systems*
CLR-5 :	*Practice the tasks inany one of image processing software like MATLAB or OpenCV*
CLR-6:	*Be Familiar with components of machine vision, image processing and its applications in industries*

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 basic concepts of digital image processing.*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*	*L*	-	-	*L*	*M*	-	-	*H*	*H*	*M*
CLO-2 :	*Learn the image fundamentals and mathematical transforms necessaryfor image processing*	*1&2*	*90*	*85*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	*M*	-	-	*H*	*H*	*M*
CLO-3 :	*Study the various image enhancement and compression techniques*	*1*	*90*	*85*	*H*	*L*	*L*	*M*	*H*	-	-	-	-	*M*	-	-	*H*	*H*	*M*
CLO-4 :	*Understand the existing machine vision systems and technique for template matching and feature extraction*	*1&2*	*90*	*85*	*H*	*L*	*L*	*M*	*H*	-	-	-	-	-	-	*M*	*H*	*H*	*M*
CLO-5 :	*Application of Machine Vision in experimental mechanics and basics of 3D Vision*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*	*M*	*M*	-	-	-	-	*M*	*H*	*H*	*M*
CLO 6:	*Learn machine vision components and basics of Image Processing*	*1&2*	*90*	*85*	*H*	*L*	*M*	*M*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	*M*

		IMAGE ACQUISITION AND FUNDAMENTALS OF IMAGEPROCESSING	IMAGE TRANSFORMS AND EDGE DETECTION	IMAGE ENHANCEMENT AND COMPRESSION	MACHINE VISION AND 3D VISION	MACHINE VISION APPLICATIONS
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Elements of visual perception, structure of eye*	*The Basics of Intensity Transformations and Spatial Filtering*	*Histogram modification and specification techniques*	*Review of existing vision systems*	*Digital Image Correlation DIC*
S-2	SLO-1	*Introduction to image processing, classification of image,*	*One-dimensional discrete fourier transform (DFT)*	*Image smoothing, Low pass filtering, Ideal low pass filter,*	*Binary and Gray vision system Vision system*	*DIC in sheet metal forming, experimental mechanics*
S-3	SLO-1	*Fundamental steps involved in image processing, sourceof image*	*Two- dimensional discrete fourier transform (DFT)*	*Butterworth low pass filter*	*Image Analysis methods, Feature extraction*	*Stereo vision in experimental mechanics*
S-4	SLO-1	*Image acquisition and digitization ,sensing*	*Cosine and Sine transform and their properties*	*Image sharpening, Butterworth filters*	*Image interpretation Segmentation*	*Electronic and automotive Industrial Applications*
S-5	SLO-1	*Illumination and its types*	*Hadamard and Haar transform and their properties*	*Generation of spatial masks from frequency domain specification,*	*Template Matching*	*Camera Calibration*
S-6	SLO-1	*CCD and CMOS Cameras*	*Slant, KL, SVD transforms and their properties*	*Basic steps in frequency domain filtering*	*Classification of 3-D Vision Techniques*	*Dimensional measurements in machine vision*
S-7	SLO-1	*Representing Digital Images, Spatial and IntensityResolution, Image Interpolation*	*Edge detection and their techniques, Roberts operator,*	*Nonlinear filters, function, Max filter, Min filter*	*Photometric stereo*	*Assembly Inspection*
S-8	SLO-1	*Problems on quantization and sampling*	*Problems based on FFT,DFT*	*Run length coding*	*Structured Light Reconstruction*	*Food processing Industrial applictaions*
S-9	SLO-1	*Practice on reading image and exercise on spatial resolution and sampling in MATLAB or Open CV*	*Practice on image transformation in MATLAB or Open CV*	*Practice on image filtering in MATLAB or Open CV*	*Assignments on feature extraction in MATLAB/Open CV*	*Practice on photometric stereo MATLAB Or Open CV*

Learning Resources	1. *Anil K. Jain, "Fundamentals of Digital Image Processing", Prentice Hall of India, New Delhi, 2007.* 2. *Rafel.C.Gonzalez and Richard E.Woods, "Digital Image Processing", Addison Wesley, New York,2009.* 3. *Vernon, D., "Machine Vision - Automated Visual Inspection and Robot Vision", Prentice Hall International Ltd., New York, 1991.* 4. *William K. Pratt, "Digital Image Processing", John Wiley, New York, 2007.*	5. *Sid Ahmed M. A., "Image Processing Theory, Algorithms and Architectures", McGraw-Hill, New York,1995.* 6. *Umbaugh.S.E, "Computer Vision and image processing - Practical approach using CVIP tools, Prentice Hall of India, New Delhi, 1998.* 7. *Ramesh Jain, RangacharKasturi and Brain G. Schunk, "Machine Vision", McGraw Hill International Editions, Computer Science Series, Singapore, 1995.* 8. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1998 Edition, Prentice Hall*

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.,
SLO – Session Learning Outcome

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.S.A.Krishnan, IGCAR,kalpakkam	*Dr.N.Arunachallam, IITM*	*Dr. A.Vijaya, SRMIST*
Mr. Narasimhan Sridhar, TESA Engg, Chennai	*Dr.A.Jothilingam, Visiting Faculty, MIT, Anna University*	*Dr. R. Senthilnathan , SRMIST*

Course Code	18MEO121T	Course Name	MULTIDISCIPLINARY DESIGN	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
CLR-1 :	*develop appropriate skills on systemic thinking on how to identify and formulate a problem, evaluate the conceptual design by using scientific, engineering and managerial tools, and to understand the current trend for the problem.*			
CLR-2 :	*rationalize the product design problem by selecting appropriate design variables, parameters and constraints from the published article*			
CLR-3 :	*subdivide a complex system into smaller disciplinary models, analyze the output and reintegrate them into an overall system model and optimize the output*			
CLR-4 :	*apply Multi objective optimization for the output to reintegrate them into an overall efficient system model*			
CLR-5 :	*take on the challenges of team work, prepare a presentation in a professional manner.*			
CLR-6 :	*understand how the various multi-disciplinary fields interact and integrate in real life situations. Develop appropriate skills on systemic thinking , evaluate the conceptual design by using scientific, engineering and managerial tools, analyze and interpret the data, considering safety, socio-politico-cultural, risks and hazards, disposal, regional and national laws, costing and financial model and undertake documentation with a presentation.*			

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 :	*develop appropriate skills on systemic thinking on how to identify and formulate a problem, evaluate the conceptual design by using scientific, engineering and managerial tools, and to understand the current trend for the problem.*	*2*	*80*	*70*
CLO-2 :	*rationalize the product design problem by selecting appropriate design variables, parameters and constraints from the published article*	*2*	*85*	*75*
CLO-3 :	*subdivide a complex system into smaller disciplinary models, manage the output and reintegrate them into an overall system model and optimize the output*	*2*	*75*	*70*
CLO-4 :	*apply Multi objective optimization for the output to reintegrate them into an overall efficient system model*	*2*	*85*	*80*
CLO-5 :	*take on the challenges of teamwork, prepare a presentation in a professional manner*	*2*	*85*	*75*
CLO-6 :	*develop appropriate skills on systemic thinking on how to identify and formulate a problem, decompose the problem into smaller elements, conceptualize the design, evaluate the conceptual design by using scientific, engineering and managerial tools, select, analyze and interpret the data, consideration of safety, socio-politico-cultural, risks and hazards, disposal, regional and national laws, costing and financial model and undertake documentation and finally with a presentation.*	*2*	*80*	*70*

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*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*H*	*H*
CLO-2 :	*H*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*H*	*H*
CLO-3 :	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	-	*H*	*H*	*H*
CLO-4 :	*H*	*H*	*M*	*M*	*M*	-	-	-		-	-	-	*H*	*H*	*H*
CLO-5 :	*H*	*H*	*H*	*H*	*H*	-	-	-	*H*	-	-	-	*H*	*H*	*H*
CLO-6 :	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	-	*H*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Identifying and Formulating research problem*	*Student presentation on literature review*	*Design of experiments -Optimization of variables to get optimized output*	*Multi objective Optimization to get optimized output and Grey relational analysis*	*Student presentation on Entropy Method*
S-2	SLO-1	*Research Process, Research Types, Research and Scientific Method*	*Student presentation on literature review*	*Response surface methodology*	*Student presentation on Grey relational analysis*	*Student presentation on Entropy Method*
S-3	SLO-1	*Problem Solving in Engineering*	*Student presentation on literature review*	*Analysis of variance (ANOVA)*	*Student presentation on Grey relational analysis*	*Student presentation on Entropy Method*
S-4	SLO-1	*Identification of Research Topic*	*Report preparation about Literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Grey relational analysis*	*Introduction to TOPSIS Method*
S-5	SLO-1	*Problem Definition*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Grey relational analysis*	*Student presentation on TOPSIS Method*

S-6	SLO-1	*Problem Solving in Engineering*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Grey relational analysis*	*Student presentation on TOPSIS Method*
S-7	SLO-1	*Collect primary data and secondary data*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Introduction to Entropy Method to calculate weights of the TOPSIS Method*	*Student presentation on TOPSIS Method*
S-8	SLO-1	*Student presentation on literature review*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Entropy Method*	*Student presentation on TOPSIS Method*
S-9	SLO-1	*Student presentation on literature review*	*Student presentation on literature survey*	*Students presentation on Response surface methodology and Analysis of variance (ANOVA)*	*Student presentation on Entropy Method*	*Student presentation on TOPSIS Method*

Learning Resources	1. *Douglas C Montgomery, " Design and Analysis of Experiments" , John Wiley & Sons Ltd., 2005* 2. *Ganesan R, "Research Methodology for Engineers" , MJP Publishers., 2011* 3. *Rao Singaresu.S, "Engineering Optimization – Theory & Practice", New Age International (P) Limited,New Delhi, 2009.* 4. *P.C.Tewaria, Ujjwal Prakash, Dinesh Khanduja, Sandeep,"Ranking of Sintered Material for High Loaded Automobile Application using Entropy-Topsis method", Materials Today: Proceedings, 2015,Pp.2375 – 2379*	5. *Suneesh. E,Multi-response optimisation of micro-milling parameters through GRA, TOPSIS and Taguchi techniques to increase production rate while reducing energy consumption, Measurement, https://doi.org/10.1016/j.measurement.2019.04.090.* 6. *Rom Kim, "A study on competitiveness analysis of ports in Korea and China by Entropy weight TOPSIS", The Asian Journal of Shipping and Logistics, 2016,32(4), Pp.187-194.* 7. *Statistical software-Minitab*

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

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. R. Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in, rkpearls@yahoo.com	*Dr.P.Sathiya, Professor, NIT, Trichy. psathiya@nitt.edu*	*Mrs. R.Ambigai,SRMIST*
2. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in		*Dr. M. R..Stalin John,SRMIST*

Course Code	18MHO101T	Course Name	Mechatronics	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To get an overview of Mechatronics as a design philosophy*
CLR-2 :	*To get an insight into multi-disciplinary systems*
CLR-3 :	*Familiarize the mechanical engineering aspects of mechatronics systems*
CLR-4 :	*Understand the concepts related to data acquisition and control*
CLR-5 :	*Understand the importance of modeling and model based design*
CLR-6 :	*To have a detailed idea of applying mechatronics design concepts in real world 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 :	*Conversant in mechatronics design philosophy*	*3*	*80*	*75*	*H*	*H*	*M*	*L*	*L*	-	-	-	*L*	*L*	-	*L*	*H*	*M*	-
CLO-2 :	*Ability to resolve the sub-systems and challenges involved in a larger mechatroncis system*	*3*	*85*	*80*	*H*	*H*	*M*	*M*	*L*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-3 :	*Understand the concepts related to data acquisition and control*	*2*	*75*	*70*	*H*	*M*	*L*	*M*	*L*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-4 :	*Ability to model and simulate physics based mechatronics systems*	*2*	*75*	*70*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-5 :	*Ability to understand the challenges in integration of a multi-disciplinary system*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	-	-	-	*M*	*L*	-	*L*	*H*	*M*	-
CLO-6 :	*Analyze the functionality of a multi-disciplinary system from the perspective of integration*	*2*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	*L*	*L*	-	*L*	*H*	*M*	-

		Introduction to Mechatronics	Mechanical and Actuation Systems	Data Acquisition and Control	Modelling and Simulation	Case Studies
Duration (hour)		7	10	10	8	10
S-1	SLO-1	*Definition of mechatronics*	*Fundamental laws governing mechanical systems*	*Sensors in mechatronics systems*	*Significance of modeling*	*Modelling of a serial robot manipulator*
	SLO-2	*Evolution of mechatronics systems*	*Actuation subsystem in Mechatronics systems*	*Sensor characteristics*	*Example*	*Need of model based design for the system under consideration*
S-2	SLO-1	*Multidisciplinary nature of modern machines and their design challenges*	*Kinematic chains, transmission elements*	*Sensor signal types*	*Model-In-Loop(MIL) simulation*	*Benefits of model based design*
	SLO-2	*Example*	*Types, purpose and examples*	*Analog and digital signals*	*Example*	*Understanding the system under consideration*
S-3	SLO-1	*Traditional vs mechatronics approaches*	*Gears*	*Motion encoder, types*	*Software-In-Loop(SIL) simulations*	*Mechanical and electronics description*
	SLO-2	*Example*	*Types, selection criteria, nomenclature*	*Specifications and selection criteria*	*Example*	*Mathematical description of the model*
S-4	SLO-1	*Mechatronics design process*	*Lead screws and belt drives*	*Incremental optical encoder*	*Virtual Prototyping- a critical aspect of mechatronics approach*	*Mathematical modeling- derivation*
	SLO-2	*Need for design tools integration*	*Types, selection criteria, nomenclature*	*Quadrature decoding - Hardware method*	*Example*	*Control strategy*
S-5	SLO-1	*Review of key elements of mechatronics systems*	*Mechanical aspects of actuator selection*	*Quadrature decoding - Software method*	*Real-time (RT) simulations*	*Analysis of performance*
	SLO-2	*Example*	*Types of actuators*	*Absolute encoder decoding*	*Example*	*Analysis of performance*
S-6	SLO-1	*Role of mechatronics engineer.*	*Comparison of electrical, pneumatic and hydraulic actuators*	*Elements of a data acquisition system*	*concurrent development of subsystems*	*Modelling of a active suspension*
	SLO-2	*Various steps for design*	*Special purpose actuators*	*Signal conditioning systems*	*Example*	*Need of model based design for the system under consideration*
S-7	SLO-1	*Various Mechatronics systems*	*Example circuit design of a servo pneumatic actuation system*	*Analog to digital conversion*	*Real-time Hardware-In-Loop simulation (HIL)*	*Benefits of model based design*
	SLO-2	*Various Mechatronics systems*	*Case study*	*Computer hardware aspects of data*	*Example*	*Understanding the system under*

				acquisition		*consideration*
S-8	SLO-1		*Step motors, types*	*Introduction to state space modelling*	*Running the controller model and plant model on real-time target*	*Mechanical and electronics description*
	SLO-2		*Construction and selection criteria*	*Modelling of a DC motor*	*V&V using HIL RT model.*	*Mathematical description of the model*
S-9	SLO-1		*Electronic drives for electrical actuators*	*Introduction to PID Control*		*Mathematical modeling- derivation*
	SLO-2		*Types, pupose and selection criteria*	*Derivation*		*Control strategy*
S-10	SLO-1		*DC motor drives - any one type*	*State space model of a speed control of a DC motor*		*Analysis of performance*
	SLO-2		*AC motor drives - any one type*	*Derivation*		*Analysis of performance*

Learning Resources	*1. Devdasshetty, Richard A.Kolk "Mechatronics Systems Design", 2nd Edition, Cengage Learning, 2011.* *2. W. Bolton, "Mechatronics", 5th Edition, Pearson Education, 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	*30 %*	-	*30 %*	-	*30 %*	-	*20 %*	-	*40%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*30%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*40 %*	-	*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
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2. Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Mr. K. Sivanathan, SRMIST*

Course Code	18MHO102T	Course Name	Model Based System 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	Mechatronics Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
CLR-1 :	*Understand the processes, methods, and practices of model-based systems engineering(MSBE)*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-2 :	*Comprehend the conflicting requirements of complex engineering systems and their life cycle stages through some relevant case studies and relate the need for model based system engineering*			
CLR-3 :	*Define and develop requirements, architectures, behavior, specifications, verifications, and tests that represent engineering systems using model-based systems engineering.*			
CLR-4 :	*Analyze systems using model-based systems engineering approaches that lead to better and increased design metrics of systems*			
CLR-5 :	*Apply the knowledge of model based system engineering for creating models using SysML diagrams that accurately represent views of engineering systems and analyze the same for improving the performance.*			

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 :	*Ability to describe the processes, methods, and practices of model-based systems engineering*	*2*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*H*	*H*
CLO-2 :	*Recognize the conflicting requirements of complex engineering systems and their life cycle stages through some relevant case studies and relate the need for model based system engineering*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	*-*	*M*	*-*	*-*	*-*	*-*	*H*	*M*	*M*	*M*
CLO-3 :	*Develop and relate requirements, architectures, behavior, specifications, verifications, and tests that represent cyber-physical systems using model-based systems engineering methods.*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	*-*	*M*	*M*	*-*	*-*	*M*	*H*	*M*	*M*	*M*
CLO-4 :	*Demonstrate analysis of systems using model-based systems engineering approaches that lead to better and increased design metrics of systems*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	*-*	*M*	*M*	*-*	*-*	*M*	*H*	*M*	*M*	*M*
CLO-5 :	*Apply the knowledge of model based system engineering to create effective models using SysML diagrams that accurately represent views of engineering systems and analyze the same for improving the performance.*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*H*	*-*	*M*	*M*	*-*	*-*	*M*	*H*	*M*	*M*	*M*

		Foundations to Model Based System Engineering(MSBE)	Modeling, Analysis and Management of System Requirements	Modeling and Simulation of Structures and Behaviors of Systems	Definition of Cyber Physical Systems and Components	Verification and Validation
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of complex engineering systems*	*Requirement of engineering artifact modeling*	*Multidisciplinary design modeling requirements*	*Definition of components and systems*	*V&V techniques overview*
	SLO-2	*Motivation for system engineering/ model based system engineering (MBSE)*	*Requirement of engineering artifact modeling*	*Multidisciplinary design modeling requirements*	*Definition of components and systems*	*V&V techniques overview*
S-2	SLO-1	*The system engineering process*	*Eliciting Requirements*	*Structural modeling*	*Assigning behaviors to components*	*Verification techniques: software engineering techniques*
	SLO-2	*Typical application of system engineering process*	*Eliciting Requirements*	*Structural modeling*	*Assigning behaviors to components*	*Formal verification technique*
S-3	SLO-1	*Multidisciplinary systems engineering team*	*Requirement modeling*	*Structural modeling using SysML*	*Incorporating images in to the model*	*Program analysis technique*
	SLO-2	*System engineering practice through standards*	*Requirement modeling*	*Structural modeling using SysML*	*Incorporating images in to the model*	*V&V of engineering design models*
S-4	SLO-1	*Contrasting document based approach and model based approach*	*Requirements management*	*Behavioral model using states and transitions*	*Allocation*	*V&V of engineering design models- Tool support*
	SLO-2	*Contrasting document based approach and model based approach- introduce SysML diagrams and MSBE tool*	*Requirements management*	*Behavioral model using states and transitions*	*Allocate activity partition*	*Automatic approach for synergistic verification and validation*
S-5	SLO-1	*Modeling principles- Model and MSBE method definition*	*Requirements Diagram, Traceability Hierarchy Diagram*	*Behavioral model in SysML*	*Unit, dimension and data types*	*Synergistic verification and validation methodology*
	SLO-2	*The purpose for modeling a system*	*Requirements Diagram, Traceability Hierarchy*	*Behavioral model in SysML*	*Adding constraints*	*Dedicated V&V approach for system*

			Diagram			*engineering*
S-6	SLO-1	*Model validation*	*Hazard analysis and threat modeling*	*Ensuring consistency*	*Activity diagrams*	*Verification and validation of behavioral diagrams*
	SLO-2	*Model metrics*	*Hazard analysis and threat modeling*	*Solving inconsistency*	*Interaction diagrams*	*Verification and validation of behavioral diagrams*
S-7	SLO-1	*Introducing the concept of architectures*	*Creating requirements models of systems using SysML in different contexts and views*	*The relationship between behavioral diagrams and structure level*	*Case study: MBSE approach for Elevator*	*Probability model checking of SysML activity diagrams*
	SLO-2	*Requirements*	*Creating requirements models of systems using SysML*	*The relationship between behavioral diagrams and structure level*	*Case study: MBSE approach for Elevator*	*Probability model checking of SysML activity diagrams*
S-8	SLO-1	*System's life cycle*	*Creating requirements models of systems using SysML in different contexts and views*	*Identifying complexity through different levels of abstraction and refinement*	*Case study: MBSE approach for ATM*	*Performance analysis of time-constrained activity diagrams*
	SLO-2	*System's life cycle*	*Creating requirements models of systems using SysML in different contexts and views*	*Identifying complexity through different levels of abstraction and refinement*	*Case study: MBSE approach for ATM*	*Performance analysis of time-constrained activity diagrams*
S-9	SLO-1	*Design and integration process*	*The SysML Use Case Diagram*	*Independent views of the same system*	*Case study: MBSE approach for automobile*	*Case study –Demonstration of V&V*
	SLO-2	*Types of systems*	*SysML Blocks and Block definition diagram*	*Concluding remarks*	*Case study: MBSE approach for automobile*	*Case study –Demonstration of V&V*

Learning Resources	1. *Dennis M.Buede & William D.Miller., "The Engineering Design of Systems Models and Methods" 3rd Edition, Wiley, 2016* 2. *Jon Hold and Simon Perry., "SysML for System Engineering", The Institution of Engineering and Technology, 2nd Edition, Wiley,2013* 3. *Kossiakoff, A. Sweet, Seymour, S., W.N., Biemer, S.M., "Systems Engineering Principles and Practice", John Wiley & Sons, 2nd Edition, 2011.* 4. *Mourad Debbabi, Fawzy Hassaine., "Verification and validation in Systems Engineering", 1st Edition, Springer, 2010.*	5. *Brian Berenbach & Daniel Paulish., "Software and Systems Requirements Engineering in Practice", 1st edition McGraw Hill, 2009* 6. *David D.Walden, Garry J.Roelder, Kevin J.Forsberg, R.Douglas Hamelin, Thomas M.Shortell., "INCOSE Systems Engineering Handbook- A Guide for System Life Cycle Processes and Activities" Wiley, 4th Edition, 2015* 7. *Sanford Friedenthal, Alan Moore ,Rick Steiner., "A Practical Guide to SysML The Systems Modeling Language", 3rd Edition, Elsevier, 2015*

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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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
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2. Dr. Guna Surendra, Gossamsetti, Hitachi, Japan. surendra.gossamsetti.bu@hitachi.com	*2. Dr. D. Sathia Narayanan, National Institute of Ocean Technology, Chennai, sathianarayanan@niot.res.in.*	*2. Dr.R.Senthilnathan, SRMIST*

Course Code	18MHO103T	Course Name	INTRODUCTION TO ROBOTICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Introduce the various architectures of industrial robot*
CLR-2 :	*Introduce the vector transformation applied to robotics*
CLR-3 :	*Introduce the forward and inverse kinematics applied to serial manipulator robot*
CLR-4 :	*Emphasize on the various actuators and transmission element used in robot.*
CLR-5 :	*Introduce the parallel configuration of robot and its kinematics computation.*
CLR-6 :	*To define various control strategy used in manipulator robotics*

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 architecture and basic technical terms used in robotics*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	-	-
CLO-2 :	*Apply vector transformation in robotics*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	-	-
CLO-3 :	*Abilityto compute the forward and inverse kinematics of serial manipulator*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*H*	-	-	*H*	*H*	-	-
CLO-4 :	*Understand the various actuators and transmission elements used in robot.*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-
CLO-5 :	*Understand the parallel configuration of robot, their kinematics computation.*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-
CLO-6 :	*Implement various control and trajectory planning algorithm*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-

		Introduction to Robotics	Transformations	Kinematics	Introduction to robot sensors and control	Parallel Manipulator and industrial work cell
Duration (hour)		7	7	11	10	10
S-1	SLO-1	*Definition of Robot, Laws of Robotics,*	*Description of point in space*	*Introduction to manipulator kinematics*	*Basic actuators and transmission elements*	*Introduction to parallel manipulator*
	SLO-2	*Basic terminologies used in robotics*	*Description of body in space*	*Forward and inverse kinematics*	*Mathematical model of DC motor*	*Advantage of parallel manipulator over serial manipulator*
S-2	SLO-1	*Classification based on application*	*Translation and Rotation*	*Forward Kinematics of RR planar manipulator- geometric approach*	*Harmonic Drives*	*Degree of freedom of parallel manipulator using Gruebler equation*
	SLO-2	*Classification based on work volume*	*Derivation of rotation matrix to represent frame orientation in XYZ axes*	*Inverse Kinematics of RR planar manipulator- geometric approach*	*Computation of reduction ratio of harmonic drive and its advantage*	*Problem on finding degree of freedom of planar and spatial mechanism*
S-3	SLO-1	*Definition – precision, repeatability and accuracy*	*various rotation representation and their difference*	*DH formulation*	*Force sensor*	*Types of parallel manipulator*
	SLO-2	*Co-ordinate systems used in robotics, Degree of freedom with examples*	*Euler angle, fixed angle , arbitrary axis representation*	*Difference between modified and standard DH convention with example of RR planar manipulator*	*Various tactile sensors- principle and working*	*Examples*
S-4	SLO-1	*Links and various joints in robotics*	*Properties of rotation matrix*	*Forward kinematics of 3R spatial articulated arm*	*Slip sensor*	*Kinematics of parallel manipulator*
	SLO-2	*Anatomy of Robot*	*Homogeneous transformation*	*Derivation of final DH matrix for 3R spatial articulated arm*	*Slip sensor*	*Concept of inverse and forward kinematics*
S-5	SLO-1	*RPY wrist*	*Case study- problems on pure rotation (current and fixed axis)*	*Forward kinematics of 4 DOF SCARA robot*	*Vision system for robot*	*Inverse kinematics of planar parallel manipulator*
	SLO-2	*Configuration space and operational space*	*Case study –problem on rotation and translation*	*Derivation of final DH matrix for 4 DOF SCARA robot*	*Vision architecture block diagram*	*Derivation*
S-6	SLO-1	*Robot data sheet interpretation*	*Operators and mapping*	*Forward kinematics of RPY wrist*	*Introduction-trajectory planning. joint space and Cartesian space planning*	*Inverse kinematics of spatial parallel manipulator*
	SLO-2	*Important terms and finding in datasheet of*	*Case study - operators and mapping*	*Derivation of final DH matrix for RPY wrist*	*Choice of joint space and Cartesian space*	*Derivation*

		manufacturer			*trajectory planning*	
S-7	SLO-1	*Robot End-effector*	*Compound transformation*	*Inverse Kinematics - closed loop form*	*Cubic polynomial trajectory planning*	*Robot work cell layout*
	SLO-2	*Types of gripper*	*Case Study – compound Transformation*	*Computation method and issues*	*Problem on cubic polynomial trajectory planning*	*Classification of robot work cell*
S-8	SLO-1			*Inverse kinematics of a 3 DOF spatial articulated arm*	*Robot position control*	*Multiple robot*
	SLO-2			*Numerical*	*Position control of one DOF link*	*Work cell control*
S-9	SLO-1			*Velocity kinematics introduction and Jacobian*	*Robot force control*	*Safety monitoring*
	SLO-2			*Understanding and deriving Jacobian matrix elements*	*Case study- force control (peg in a hole)*	*Error detection and recovery*
S-10	SLO-1			*Derivation of Jacobian matrix for RR planar manipulator*	*Hybrid force/position control*	*Robot Cycle time analysis*
	SLO-2			*Concept of singularity for manipulator*	*Case Study of hybrid force/position control*	*Criteria for selection of robot work cell*
S-11	SLO-1			*Computing Jacobian for RRR spatial manipulator*		
	SLO-2			*Computing singularity for a RRR spatial manipulator*		

Learning Resources	*1. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012* *2. John J. Craig, "Introduction to Robotics", 3rd Edition, Addison Wesley, ISE 2008.* *3. Deb S.R., "Robotics Technology and Flexible Automation", 2nd edition, Tata McGraw - Hill Publishing Company Limited, 2012.*	*4. Arthor Critchlow, "Introduction to Robotics",1st edition, Macmillan, 2009.* *5. Mohsen Shahinpoor, "A Robot Engineering Text Book", 1st edition, Harper and Row, 2004* *6. Sterling Kinney J, "Indeterminate Structural Analysis", 1st edition, Narosa Publishing House, 1987.*

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
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2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. Dr. R Senthilnathan, SRMIST*

Course Code	18NTO301T	Course Name	APPLICATIONS OF NANOTECHNOLOGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on environmental applications of nanotechnology*
CLR-2 :	*Understand the theory of nanotechnology in agriculture and food technology*
CLR-3 :	*Familiarize electrical, electronics and energy applications of nanotechnology*
CLR-4 :	*Know nanotechnology in textiles and cosmetics*
CLR-5 :	*Explore the concept of biomedical applications of nanotechnology*
CLR-6:	*Understand the current developments and future prospects of nanotechnology*

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 :	*Apply skills to identify new materials for environmental applications*	*2*	*80*	*75*
CLO-2 :	*Analyze the role of nanotechnology in agriculture and food technology*	*2*	*80*	*70*
CLO-3 :	*Discriminate electrical, electronic and energy applications of nanotechnology*	*2*	*75*	*70*
CLO-4 :	*Apply the techniques of nanotechnology in textile and cosmetics*	*2*	*80*	*75*
CLO-5 :	*Appreciate the role of nanotechnology in advancing the biomedical industry*	*2*	*80*	*70*
CLO-6:	*Utilize the concept of biosensor to analyze the material nature.*	*2*	*80*	*75*

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*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*
H	*M*	*M*	*H*	*M*	*H*	*H*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
H	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
M	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
H	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Environmental pollutants in air*	*Nanotechnology in Agriculture*	*Electronic circuit chips*	*Nanofibre production in Textiles*	*Introduction to biomedical applications*
	SLO-2	*Environmental pollutants in water*	*Precision farming*	*Nanosensors and actuators*	*Electrospinning*	*Bioreceptors and their properties*
S-2	SLO-1	*Environmental pollutants in soil*	*Smart delivery system*	*Optical switches*	*Controlling morphologies of nanofibers*	*Biochips*
	SLO-2	*Types of toxic and hazards wastes*	*Nanofertilizers and types*	*Diodes*	*Nano-fillers embedded polypropylene fibers*	*Integrated nanosensor*
S-3	SLO-1	*Application of nanotechnology - Introduction*	*Nanourea and mixed fertilizers*	*Nano-wire transistors*	*Bionics*	*DNA based biosensors*
	SLO-2	*Application of nanotechnology in industrial waste*	*Nanofertigation*	*Advantages of nano electrical and electronic devices*	*Swim-suits with shark-skin effect*	*Natural nanocomposite systems*
S-4	SLO-1	*Application of nanotechnology in waste water treatment*	*Nanopesticides*	*Memory storage*	*Soil repellence*	*Nanomaterials in bone substitutes and dentistry*
	SLO-2	*Drinking water purifications*	*Nanoseed Science*	*Lighting displays and filters*	*Lotus effect*	*Implants and Prosthesis*
S-5	SLO-1	*Air purifications*	*Nanotechnology in Food industry*	*Quantum computers*	*Nano finishing in textile*	*Tissue Engineering*
	SLO-2	*Gas purifications*	*Nanopackaging for enhanced shelf life*	*Medical diagnosis and conductive additives*	*Modern textiles Nanopolymers in medical textiles*	*Neuroscience*
S-6	SLO-1	*Nanomonitoring*	*Smart packaging*	*Lead-free solder*	*Introduction to cosmetics*	*Neuro-electronic Interfaces*
	SLO-2	*Nano Biosensors - Overview*	*Intelligent packaging*	*Nanocoatings and EMI shielding.*	*Formulation of Gels*	*Nanorobotics*
S-7	SLO-1	*Nano Biosensors for Pesticide Detection*	*Food processing*	*Energy devices*	*Shampoos*	*Photodynamic Therapy*
	SLO-2	*Nano Biosensors for Plant Pathogen Detection*	*Food safety*	*Fuel cells*	*Hair-conditioners*	*Protein Engineering*
S-8	SLO-1	*Nano Bioremediation*	*bio-security*	*role of nanomaterials in fuel cell applications*	*Introduction to Sun-screen dispersions*	*Nanosensors in Diagnosis*
	SLO-2	*Pesticide Degradation*	*Electrochemical sensors*	*Photovoltaic cells*	*Sun-screen dispersions for UV protection*	*Drug delivery*
S-9	SLO-1	*Soil Structure*	*sensors for food analysis*	*Application of nanotechnology in solar cells*	*Colour cosmetics*	*Cancer therapy*
	SLO-2	*Soil structure Remediation*	*contaminant detection*	*Application of power in transportation*	*Types of Colour cosmetics*	*Other therapeutic applications*

Learning Resources	1. *Environmental Nanotechnology, by M. H. Fulekar, Bhawana Pathak* 2. *Lynn J. Frewer, Willehm Norde, R. H. Fischer and W. H. Kampers, Nanotechnology in the Agri-food sector, Wiley-VCH Verlag, (2011).* 3. *Jennifer Kuzma and Peter VerHage, Nanotechnology in agriculture and food production, Woodrow Wilson International Center, (2006).*	4. *P. J. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead Publishing Limited,Cambridge, (2007).* 5. *Neelina. H, Malsch (Ed.), "Biomedical Nanotechnology", 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. N. Vijayan, CSIR-NPL, nvijayan@nplindia.org	*1. Prof. S. Balakumar, University of Madras, balakumar@unom.ac.in*	*Dr.J.Archana, SRMIST*
2. Dr. Krishna SurendraMuvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. V. Subramaniyam, IIT Madras, vsubbu@iitm.ac.in*	*Dr.S.Harish, SRMIST*

Course Code	18NTO302T	Course Name	SOLID STATE ELECTRONIC DEVICES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Realize the basics of solid state physics with particular emphasis on semiconductors.*
CLR-2 :	*Provide in-depth understanding of diodes, acquire knowledge of various types and operation of diodes.*
CLR-3 :	*Develop key understanding related to basics of transistors along with processes involved in working of transistors*
CLR-4 :	*Understand the important ingredient towards technological application of transistors, specifically, field effect transistors*
CLR-5 :	*Get acquainted with various solid state devices and application.*
CLR-6 :	*Develop idea about few exemplary real commonly used electronic 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 :	*Appreciate the importance of "solid state devices" for the advancement of technology*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze diodes and understand its significance in technological application*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Obtain the knowledge on the transistors and its working principles*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Achieve knowledge about variety of transistors and difference between various transistors*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Evaluate the working principles of existing devices based on solid state electronics*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Get an idea of future device application in advancing the existing technology for power efficient devices*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Brief introduction to crystal structure in solids*	*Basic structure of p-n junction*	*Basics of Bipolar transistors*	*Introduction to Field Effect Transistors (FET)*	*Introduction to light emitting diode (LED)*
	SLO-2	*Electronic band structure*	*Current transport in p-n junction diode*	*Usefulness of transistors*	*Working principle of FET*	*Working principle of LED*
S-2	SLO-1	*Detailed discussion on energy bands in solids*	*I-V Characteristics, Zero applied bias: Electric field*	*Theory of operation and action of PNP*	*Junction FET*	*Different useful materials for LED*
	SLO-2	*Discussion on band structure calculation*	*Built-in potential, junction capacitance, Diffusion capacitance*	*NPN transistors*	*Theory of operation and current equation*	*Multilayers heterojunctions for LED*
S-3	SLO-1	*Elemental and compound semiconductors*	*Generation-recombination currents*	*Description of majority and minority carrier distribution*	*Introduction of Metal semiconductor FET (MOSFET)*	*Photodiodes-current and voltage in an illuminated junction*
	SLO-2	*Doping in semiconductors, Shallow and deep levels*	*Junction breakdown mechanisms*	*Terminal currents in transistors*	*Application of MOSFET*	*Exemplary description of photodiodes*
S-4	SLO-1	*Carrier statistics, Carrier transport, Carrier mobility*	*Introduction of Zener diode*	*How transistors can be used for amplification?*	*Metal oxide semiconductor FET (MOSFET): working principle*	*Photodetectors-noise*
	SLO-2	*Scattering mechanisms*	*Unique features associated with Zener diode*	*Transistor as amplifier*	*Application of MOSFET*	*Bandwidth of photodetectors*
S-5	SLO-1	*Non-equilibrium conditions, Quasi Fermi levels*	*Heterojunctions: Band alignments*	*What makes transistors to work as switch?*	*Details of VI Characteristics of MOSFET*	*Semiconductor lasers*
	SLO-2	*Recombination processes*	*Energy band diagrams of heterojunctions*	*Application of transistor as switch*	*Qualitative description of VI characteristics of MOSFET*	*Population inversion at a junction*
S-6	SLO-1	*Understanding current density*	*Formation of two dimensional electron gas*	*How transistors can be used for switching?*	*Depletion and enhancement types - threshold voltage*	*Detailed description of emission spectra for p-n junction lasers*
	SLO-2	*Mathematical description of continuity equations*	*Qualitative description of two dimensional electron gas*	*Summary of transistor application*	*Gate capacitance inversion and accumulation layers*	*Quantitative interpretation of emission spectra for p-n junction lasers*
S-7	SLO-1	*Surface recombination*	*Metal-semiconductor contacts*	*Open-circuited transistors-biasing in active region,*	*Complementary MOSFET*	*Heterojunction lasers-materials for semiconductor lasers*

	SLO-2	*Surface states*	*Schottky barrier diode*	*Ways to bias a transistors*	*Significance of CMOSFET*	*Semiconductor laser applications*
S-8	SLO-1	*Excitons in semiconductors*	*Fermi level pinning*	*Detailed description of Schottky transistors*	*Introduction to high electron mobility transistor (HEMT)*	*Introduction to Solar cells*
	SLO-2	*How to estimate carrier concentration?*	*C-V characteristics of a Schottky diode*	*Working principles of Schottky transistors*	*Ways to achieve HEMT*	*Relevance of semiconducting materials in solar cell application*
S-9	SLO-1	*Discussion on Hall effect measurements*	*Current transport processes*	*Detailed description of Optical transistors*	*Working principle of charge coupled devices (CCD)*	*Transistors as building block of memory devices*
	SLO-2	*Discussion on fractional quantum Hall effect*	*I-V characteristics*	*Application of Optical transistors*	*Interpretation of information obtained from CCD*	*Advanced solid state memory devices*

Learning Resources	*1. Solid State Electronic Devices, by Streetman and Ben Garland, Prentice Hall, 2000* *2. Physics of Semiconductor Devices, by S. M. Sze and Kwok. K. Ng, John Wiley & Sons, Inc., 2007*	*3. Art of Electronics, by Horowitz and Hill, Cambridge University Press, 2nd ed., 1989*

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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. Hemant Dixit, Global Foundaries,USA, aplahemant@gmail.com	*1. Dr. Debanjan Bhowmik, IIT Delhi, debanjan@ee.iitd.ac.in*	*1. Dr. Jaivardhan Sinha, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. S. Chandramohan, SRMIST*

Course Code	18NTO303T	Course Name	MICRO AND NANOELECTRONICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the physical effects of semiconductor-semiconductor junction, its electrostatics, and device operation*
CLR-2 :	*Learn methodology of lithography and etching to pattern materials at micro and nanoscale*
CLR-3 :	*Acquire knowledge of VLSI design and fabrication*
CLR-4 :	*Get acquainted with CMOS fabrication rules*
CLR-5 :	*Learn integrated circuit passive and component fabrication processes*
CLR-6 :	*Introduce next generation printed electronics technology*

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 working of semiconductor devices in its large scale operation*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Pattern diverse materials using lithography techniques to enhance the device density on chip*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Design the VLSI components*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Fabricate small-scale devices and chip level device space management*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Imagining importance of nanoscale devices*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Envision low cost production of electronic devices using printed technology*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Fundamentals of Electronic Devices*	*Need and basics of lithography*	*History of complementary metal-oxide-semiconductor (CMOS)*	*Integrated circuit fabrication technology*	*Overview of flexible electronics*
	SLO-2	*Overview of semiconductor Physics*	*Optical lithography*	*CMOS processing: LOCOS and STI isolation*	*Moor's law and scaling*	*Advantages of printing*
S-2	SLO-1	*Intrinsic semiconductors*	*Optical lithography controls*	*Layout design rules*	*Passive component fabrication*	*Requirements of printing*
	SLO-2	*Extrinsic semiconductors*	*Photo-mask making*	*Rules for: well, transistor, contact, via, etc.*	*Fabrication of integrated resistor*	*Printing tools*
S-3	SLO-1	*p-n junction formation*	*Working concept and controls of e-beam lithography*	*MOSIS Scalable CMOS Design Rules*	*Fabrication of integrated capacitor*	*Types of fluids for ink*
	SLO-2	*Charge distribution and Fermi level in p-n junction*	*Resolution of electron beam lithography*	*Micron design rules*	*Fabrication of integrated inductor*	*Properties of fluids in printing processes*
S-6	SLO-1	*Depletion region capacitance*	*Wet etching mechanism and disadvantages*	*CMOS integrated inverter working principle*	*Self-aligned gate*	*Working principle of flexographic printing (FP)*
	SLO-2	*Depletion region width and its bias dependence*	*Wet etching of silicon, silicon dioxide and metal*	*IV characteristics of inverter*	*fabrication of NMOS with polysilicon self-aligned gate*	*Advantages and disadvantages of FP*
S-7	SLO-1	*Metal-Oxide-Semiconductor (MOS) capacitor*	*Types of dry etching*	*CMOS fabrication process*	*3D transistors requirements*	*Working principle of gravure printing (GP)*
	SLO-2	*Operation of MOS capacitor*	*Ways of plasma generation for etching processes, Sputter etching*	*CMOS integrated inverter design rules*	*FinFET technology*	*Advantages and disadvantages of GP*
S-8	SLO-1	*Operation of MOSFETs in linear region*	*Capacitively coupled plasma*	*CMOS process enhancement*	*Integrated memory devices*	*Working principle of screen printing (SP)*
	SLO-2	*Operation of MOSFETs in saturation region*	*Reactive ion etching*	*Enhancement for transistor and interconnect*	*Dynamic RAM (DRAM) fabrication*	*Advantages and disadvantages of SP*
S-9	SLO-1	*Sub threshold region*	*Inductively coupled plasma*	*Manufacturing issues*	*Challenges for nanoelectronics*	*Working principle of inkjet printing (IP), Advantages and disadvantages*
	SLO-2	*MOSFET scaling*	*Deep reactive ion etching and bosh*	*Yield management*	*Requirements of nanoelectronics*	*Future of printed low-cost electronics*

			process			

Learning Resources	1. *S. M. Sze, and S. Lee, "Semiconductor Devices Physics and Technology", Wiley, 2012* 2. *Neil H. E. Weste and David Money Harris, "CMOS VLSI design", Addison-Wesley, 2011*	3. *Giovanni Nisato, Donald Lupo, Simone Ganz, "Organic and Printed Electronics", CRC Press, 2016.* 4. *Hans H. Gatzen, Volker Saile, Jürg Leuthold, "Micro and Nano Fabrication", Springer 2015*

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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. Hemant Dixit, Global Foundaries, USA, aplahemant@gmail.com	*1. Dr. A. Subrahmanyam, IIT Madras, manu@iitm.ac.in*	*1. Dr. Abhay Sagade, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. N. N. Murthy, IIT Tirupati, nnmurty@iittp.ac.in*	*2. Dr. A. Karthigeyan, SRMIST*

Course Code	18NTO304T	Course Name	ENVIRONMENTAL NANOTECHNOLOGY	Course Category	O	Open Elective Course	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	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 :	*Acquire knowledge on nanotechnology in environmental and health effects*																		
CLR-2 :	*Understand the effect of nanomaterials for environmental protection*																		
CLR-3 :	*Describes the effect of nanomaterials in environment*																		
CLR-4 :	*Explains the safety measurements*																		
CLR-5 :	*Gain knowledge on different sustainable nanotechnologies*																		
CLR-6 :	*Educate and understanding of sustainable nanotechnology*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Elucidate the effects to human health and the environment*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyze the relationships between key properties of nanomaterials and their environmental fate*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Apply the physical and chemical properties of nanomaterials*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Approach the influence of the behavior of nanomaterials in the environment and in biological systems*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Demonstrate the knowledge of mapping of the environmental fate of nanomaterials*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Elucidate the use of nanoparticles for environmental remediation and water treatment*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Nanotechnology in environmental and health effects*	*Nanomaterials for Environmental Protection*	*Identification and characterization of Hazardous waste*	*Environmental Nano Remediation Technology*	*Sustainable Nanotechnology*
	SLO-2	*Environmental pollutants in air*	*Nanotechnology processes*	*Nano Pollution*	*Thermal methods*	*Application of industrial ecology to nanotechnology*
S-2	SLO-1	*Environmental pollutants in water*	*Nano Engineering materials for Pollution Prevention*	*Air/Gas Contaminants*	*Physical methods*	*Fate of nanomaterials in environment*
	SLO-2	*Environmental pollutants in soil*	*Green Chemistry*	*Water Contaminants*	*Chemical methods*	*environmental life cycle of nano materials*
S-3	SLO-1	*Hazardous and toxic wastes*	*Energy efficient resources and materials*	*Soil Contaminants*	*Biological Methods*	*environmental impacts of nano materials*
	SLO-2	*Challenges to occupational health*	*Nanotechnology products- Nanomaterials*	*Identification and Characterization of Organic and inorganics*	*Nano Filtration methods for treatment of waste water*	*health impacts of nano materials*
S-4	SLO-1	*Challenges to occupational hygiene*	*Nanodevices and nanosystems*	*Identification and Characterization of Organic and inorganics*	*removal of organics & inorganics and pathogens*	*toxicological threats*
	SLO-2	*Toxicity of nanoparticles*	*Synthesis of nanomaterials by Physico-chemical approaches*	*Nanomaterials-Remediation*	*removal of inorganics*	*eco-toxicology*
S-5	SLO-1	*Effects of inhaled nanosized particles*	*Bio-nancomposites*	*Nano Membranes*	*removal of pathogens*	*exposure to nano particles – biological damage*
	SLO-2	*Skin exposure to nanoparticles*	*Nanoparticles and Microorganisms*	*Nano Meshes*	*Nanotechnology for water 5 remediation and purification*	*threat posed by nano materials to humans*
S-6	SLO-1	*Impact of CNTs on respiratory systems*	*Microbial Synthesis of Nanomaterials*	*Nano Fibres*	*Treatment of hi-tech industrial waste waters using nano particles/ modified structures/devices*	*environmental reconnaissance and surveillance*
	SLO-2	*Hazards of exposure to nanoparticles*	*Biological Methods for Synthesis of nano-emulsions using bacteria*	*Nano Clays and Adsorbents, Zeolites, Nano Catalysts, Carbon Nano Tubes,*	*Treatment of hi-tech industrial waste waters using modified structures*	*Corporate social responsibility for nanotechnology*
S-7	SLO-1	*Risks of exposure to nanoparticles*	*Fungi and Actinomycetes*	*Bio Polymers*	*Treatment of hi-tech industrial waste waters using dyes*	*Combining Life Cycle and Risk Assessment*

	SLO-2	*Screening of nanomaterials for understanding potential effects to human health and the environment*	*Different plants based nanoparticle synthesis*	*Single Enzyme Nanoparticles*	*Groundwater remediation*	*Proposed Solutions to prevent toxicology*
S-8	SLO-1	*Mapping of the environmental fate of nanomaterials*	*Plants based nanoparticle synthesis*	*Bio Metallic Iron Nanoparticles*	*Surface water treatment*	*Safety measurements*
	SLO-2	*Relationships between key properties of nanomaterials and their environmental fate*	*Nano composite biomaterials – Fibres*	*Nano SemiConductors*	*Titanium dioxide*	*Education and understanding of sustainable nanotechnology*
S-9	SLO-1	*Transport and transportation of nanomaterials*	*Devices and Structures*	*Photo catalysis*	*Challenges*	*Applications of nanotechnology for sustainability*
	SLO-2	*Bio-distribution and toxicity of nanomaterials*	*Nano Bio systems.*	*Nano-sensors*	*Environmental Benefits of nanomaterials*	*Nanomaterials in future - implications.*

Learning Resources	1. *Nanotechnlogy: Health and Environmental risk by Jo Anne Shatkin. CRC press, 2008.* 2. *Nanotechnologies, Hazards and Resource efficiency by M. Steinfeldt, Avon Gleich, U. Petschow, R. Haum. Springer, 2007.*	3. *Environanotechnology by Mao Hong fan, Chin-pao Huang, Alan E Bland, Z Honglin Wang, RachidSliman, Ian Wright. Elsevier, 2010.* 4. *Nanostructured conductive polymers. Edited by Ali Eftekhari. Wiley, 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. N. Vijayan, CSIR-NPL, nvijayan@nplindia.org	*1. Prof. S. Balakumar, University of Madras, balakumar@unom.ac.in*	*1. Dr. M.Navaneethan, SRMIST*
2. Dr. Krishna SurendraMuvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. V. Subramaniyam, IIT Madras, manianvs@iitm.ac.in*	*2. Dr. E. Senthil Kumar, SRMIST*

Course Code	18NTO305T	Course Name	MEDICAL NANOTECHNOLOGY	Course Category	O	Open Elective course	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understanding the basics of medicine*
CLR-2 :	*Know the various classification of nanomedicine*
CLR-3 :	*Getting knowledge about interaction of nanomaterials with biological environment*
CLR-4 :	*Gain a broad understanding about nanosystems for the diagnosis and therapy*
CLR-5 :	*Get acquainted with future aspects of nanosurgery*
CLR-6:	*Comprehend the principles behind medical nanotechnology*

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 :	*To distinguish the advantages between conventional and nanomedicine*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze the concepts of medical nanotechnology*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Apply concepts of nanomedicine to a focused clinical area of their choice*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Apply the nanosystems for diagnosis and therapy*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Apply the concepts of nanosurgery*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Apply the principle of nanomolecular tracking*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Conventional medicine*	*Nanosensors & nanoscale scanning*	*Nanoparticles for imaging & drug delivery*	*Nanodiagnostics*	*Nanodevices for Clinical Nanodiagnostics*
	SLO-2	*Prospect of nanomedicine*	*Nanosensor Technology*	*Types of Nanoparticles for drug delivery*	*Nanosensors for Diagnosis*	*Types of Nanodevices for diagnosis*
S-2	SLO-1	*Current Medical Practice*	*Chemical Nanosensor*	*Nanoparticles for medical imaging*	*Nanoarrays for Molecular Diagnostics*	*Nanoendoscopy*
	SLO-2	*Challenges in Current Medical Practice*	*Molecular Nanosensor*	*Enhancement for X-ray*	*Types of Nanoarrays*	*Uses and advantage of nanoendoscopy*
S-3	SLO-1	*Evolution of Scientific Medicine*	*Displacement Sensor*	*MRI imaging*	*Nanoparticles for Molecular Diagnostics*	*Nanobiotechnology and Drug Delivery Devices*
	SLO-2	*Drawinian medicine*	*Motion Sensors*	*IR imaging*	*Gold Nanoparticles*	*Types of Nanodevices for drug delivery*
S-4	SLO-1	*Volitional Normative Model of Disease*	*Force Nanosensor*	*Visible imaging*	*Magnetic Nanoparticles*	*Tools for Nanosurgery*
	SLO-2	*Disease Nominalism,Disease Relativism*	*Thermal Nanosensor*	*UV imaging*	*Quantum Dots for Molecular Diagnostics*	*Nanoscale Laser Surgery*
S-5	SLO-1	*Treatment Methodology*	*Electric and Magnetic Sensing*	*Nanoparticles for targeted imaging*	*DNA Nanomachines*	*Nanorobotics for Surgery*
	SLO-2	*Conventional methods*	*Cellular Bio scanning*	*Targetting moieties*	*DNA Nanomachines for Molecular Diagnostics*	*Nanotechnology for Detection of Cancer*
S-6	SLO-1	*Evolution of Bedside Practice*	*Macrosensing*	*Nanoparticles for delivery of energy*	*Nanobarcodes Technology*	*QDs for Sensing Cancer Cell Apoptosis*
	SLO-2	*Benefits of Bedside Practice*	*Intergated nanosensor technologies*	*Types of nanoparticles for delivery of energy*	*Commercially available Nanobarcodes*	*Dendrimers for Sensing Cancer Cell Apoptosis*
S-7	SLO-1	*Molecular Nanotechnology*	*Genomics*	*Nanoparticles for delivery of drugs*	*Cantilevers as Biosensors for Molecular Diagnostics*	*Gold Nanoparticles for Cancer Diagnosis*
	SLO-2	*Introduction and Basic principles*	*Methods in Genomics*	*Types of nanoparticles for delivery of drugs*	*Types of Cantilevers as Biosensors for Molecular Diagnostics*	*Nanotubes for Detection of Cancer Proteins*
S-8	SLO-1	*Pathways to Molecular Manufacturing*	*Proteomics*	*Materials for drug delivery*	*Nanodiagnostics for the Battle Field*	*Nanoparticles for the Optical Imaging of Tumors*
	SLO-2	*Molecular Transport*	*Methods in Proteomics*	*Fabrication for drug delivery*	*Uses of Nanodiagnostics for the Battle Field*	*Nanolaser Spectroscopy for Detection of Cancer in Single Cells*
S-9	SLO-1	*Molecular Sortation*	*Real-time monitoring*	*Nanocapsulation for drug delivery*	*Nanodiagnostics for Integrating*	*Nanoparticles-MRI for Tracking Dendritic*

					Diagnostics with Therapeutics.	*Cells in Cancer Therapy*
	SLO-2	*Types of Molecular Sortation*	*In vivo medical monitoring*	*Application of Nanocapsulation for drug delivery*	*Advantages of Integrating Diagnostics with Therapeutics.*	*Advantages of Nanoparticle tracking*

Learning Resources	*1. Robert .A. Freital.Jr, "Nanomedicine"- Landes Bioscience Press 2010.* *2. Harry F.Tibbals, "Medical Nanotechnology & Nanomedicine' - CRC press,2011.*	*3. Jain.K.K, "Handbook of Nanomedicine"- Springer, 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Chandru Trivitron Healthcare Pvt. Ltd. Chennai, chandru.k@trivitron.com	*1. Dr. Amit Kumar Mishra , IIT Jodhpur, amit@iitj.ac.in*	*1. Dr. Devanandh Venkata Subhu, SRMIST*
2. Dr.Nagesh Kini,Thermax,Pune,Maharastra,nagesh.kini@gmail.com	*2. Dr. Sampath Kumar T.S,IIT Madras, tssk@iitm.ac.in*	*2. Dr. Selvamurugan, SRMIST*

Course Code	18NTO306T	Course Name	NANOSCALE SURFACE ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Obtain vast knowledge on Surface and Interfaces and its structure*
CLR-2 :	*Understand the process involved in surface and Interfaces*
CLR-3 :	*Understand the Diffusion process involved in surface and related laws*
CLR-4 :	*Describe the laws related to surface phenomena*
CLR-5 :	*Gain knowledge on Surface Analysis Techniques*
CLR-6 :	*Understand the principles of XPS, UPS and ISS*

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 concept of Surface crystallography to understand the surface structure*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Able to analyze surface related process and its measurements*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Apply the concept of Fick's law to have clear a understanding on surface diffusion process*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Analyze the different mechanisms involved in surface diffusion and kinetics*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Utilize the Photoelectron spectroscopic and Secondary electron techniques to understand the properties of surface*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Analyze different types of metal and semiconducting surfaces and its properties*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to surfaces and interfaces and its related terms and definitions*	*Adsorption and desorption: Definition & Concept*	*Concept of Random-walk motion*	*Surface specificity*	*Nanoscale Characterization for Surfaces*
	SLO-2	*surface energy, surface tension and surface states*	*Various types of adsorption and desorption*	*Basic equations -random-walk motion*	*Spectrum of secondary electrons*	*Scanning tunneling microscopy (STM) – historical perspective and theory*
S-2	SLO-1	*Some basic concepts of bulk crystallography : Direct lattices and directions*	*Basics of adsorption kinetics*	*Fick's laws: Definition and its explanation*	*Photoelectron spectroscopy - Physical process: photoemission, spectral feature*	*STM: electron tunneling*
	SLO-2	*Symmetry groups and planes*	*Concept of coverage dependence*	*Fick's laws: Definition and its explanation*	*Photoelectron spectroscopy -depth specificity*	*STM imaging*
S-3	SLO-1	*Structure of the unit cell, Primitive cell in bulk crystals.*	*Coverage dependence derivation*	*Tracer diffusion*	*Photoelectron spectroscopy (XPS and UPS) - compositional information*	*Scanning tunneling spectroscopy*
	SLO-2	*Concept of ideal crystal and of ideal crystal*	*Langmuir Isotherm*	*Chemical, diffusion*	*Photoelectron spectroscopy (XPS and UPS) - elemental sensitivity*	*STM: Instrumentation*
S-4	SLO-1	*Surface structure and surface order*	*Temperature dependence Kinetics*	*Intrinsic diffusion*	*Photoelectron spectroscopy (XPS and UPS) - chemical-state information*	*Semiconductor surfaces*
	SLO-2	*Surface crystallography*	*Temperature dependence derivation*	*Mass transfer diffusion*	*Photoelectron spectroscopy (XPS and UPS) -spectral resolution and depth profiling*	*Semiconductor surfaces: Si (111)*
S-5	SLO-1	*Surface Crystallography of a plane,*	*Angular dependence Kinetics*	*Anisotropy of surface diffusion*	*Photoelectron spectroscopy (XPS and UPS) -Modular instrumentation: excitation sources*	*Semiconductor surfaces: Si (100)*
	SLO-2	*And its point and space group symmetry*	*Kinetic energy dependence Kinetics*	*Anisotropy of surface diffusion*	*Energy analyzers and detectors*	*Semiconductor surfaces: GaAs (110)*
S-6	SLO-1	*Unit mesh transformation approach*	*Thermal deposition*	*Atomistic mechanisms of surface diffusion and its types*	*Auger Electron spectroscopy (AES): physical process: photoemission*	*Photo induced process*

	SLO-2	*Wood notation description*	*Theory of Desorption kinetics*	*Atomistic mechanisms of surface diffusion: hopping mechanism*	*Ion Scattering Spectroscopy (ISS): physical process: photoemission*	*Different types involved in Photo induced process*
S-7	SLO-1	*Unit mesh transformation approach*	*Thermal desorption spectroscopy: Basic working Principle*	*Atomistic mechanisms of surface diffusion: Vacancy mechanism*	*Spectral feature and depth Specificity*	*Metal – semiconductor surfaces*
	SLO-2	*Matrix notation and classification of overlayer meshes*	*Thermal desorption spectroscopy: Instrumentation*	*Atomistic mechanisms of surface diffusion: Atomic exchange mechanism*	*AES and ISS: compositional information*	*Analysis of Metal – semiconductor surfaces properties*
S-8	SLO-1	*Electronic structure (for three dimension)*	*Adsorption Isotherms: A detailed study*	*Atomistic mechanisms of surface diffusion:Tunneling mechanism*	*AES and ISS:elemental sensitivity*	*Alkali – metal – semiconductor interfaces*
	SLO-2	*Density of States (Surface states)*	*Various types of Adsorption Isotherms*	*Atomistic mechanisms of surface diffusion:Tunneling mechanism*	*AES and ISS: chemical-state information & spectral resolution and depth profiling*	*Analysis of Alkali – metal – semiconductor interfaces properties*
S-9	SLO-1	*Surface states structure (for two dimension)*	*Non-Thermal desorption*	*Nucleation and Equilibration via Surface Diffusion*	*AES and ISS: excitation sources*	*Growth of trivalent metals on Si (001)*
	SLO-2	*Surface electronic structure (for two dimension)*	*Types of Non-Thermal desorption*	*Experimental study of surface diffusion*	*AES and ISS: energy analyzers and detectors*	*Analysis of Growth of trivalent metals on Si (001) properties*

Learning Resources	1. *John DiNardo N., "Nanoscale Characterization Of Surface And Interfaces", Wiley-VCH, 2008* 2. *Oura K., V. G. Lifshits, A. A. Saranin, A. V. Zotov and M. Katayama, "Surface Science – An Introduction" Springer, 2013*	3. *Unertl W.N., "Physical structure" Elsevier Science B. V, 2006* 4. *Riviere J.C and Myhra S., "Handbook of Surface and Interface analysis", CRC Press, 2009*

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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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.Solomon Jonnes,Bengaluru,solomon@terracarb.com	*1. Dr.Amit Kumar Mishra , IIT Jodhpur, amit@iitj.ac.in*	*1. Dr. V. Kathirvel, SRMIST*
2. Dr.Nagesh Kini,Thermax,Pune,Maharastra,nagesh.kini@gmail.com	*2. Dr.Sampath Kumar T.S, IIT Madras, tssk@iitm.ac.in*	*2. Dr. A. Alagirisamy SRMIST*

Course Code	18NTO307T	Course Name	NANOCOMPUTING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on nanoelectronics and its importance*
CLR-2 :	*Introduce the concept of molecular and optical computing*
CLR-3 :	*Understand about biocomputers and related nanomachines*
CLR-4 :	*Learn basics and advancements of quantum computing*
CLR-5 :	*Understand the architecture of processing in nanosystems*
CLR-6 :	*Gain knowledge on soft computing and neural networks*

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 basic concepts in nanocomputing*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Explain major advances in molecular and optical computing*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Recognize the evolution and advancements of biocomputers*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Utilize the knowledge in quantum computing*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Get familiarized with designing of parallel information processing machines*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Apprehend the importance of soft computing*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of computing*	*Molecular computing*	*Biological networks and neurons*	*Quantum computers-Bit and Qubit*	*Parallel Architectures for Nanosystems-Architectural principles*
	SLO-2	*Nanocomputing*	*Brief background of molecular electronics*	*Function of neuronal cell*	*Coherence and entanglement*	*Mono and multiprocessor systems*
S-2	SLO-1	*Transistors inside the Machine*	*Origin of molecular computing*	*Biology-inspired concepts*	*Quantum parallelisms*	*Some considerations to parallel processing*
	SLO-2	*Quantum computers*	*Molecular computing architecture*	*Biological Neuronal cells on silicon*	*Classical gates*	*Influence of delay time*
S-3	SLO-1	*Nanocomputing technologies*	*Some techniques of molecular computing-Adleman's landmark experiment*	*Modeling of neuron cells by VLSI circuits*	*Reversible operations*	*Power dissipation and Parallelism*
	SLO-2	*From Microelectronics to Nanoelectronics*	*DNA computation in ciliates-Bacteriorhodopsin*	*Neuronal networks with local adaptation*	*Beyond Classical Gates-Superposition*	*Architecture for processing in Nanosystems-Classic systolic arrays*
S-4	SLO-1	*From Nanoelectronics to Nanoelectronics computers*	*Challenges of molecular computing-Reliability, Efficiency and Scalability*	*Distributed data processing*	*Sqrt(NOT) operation*	*Processor with large memories*
	SLO-2	*Alternative to Transistor technology – quantum computing*	*Encoding problem-Error-preventing codes*	*Biocomputers – biochemical computers*	*Quantum algorithms-Necessity of quantum software in Conjunction with the hardware*	*Processor array with SIMD and PIP architectures*
S-5	SLO-1	*Nanoinformation processing - Prospects and challenges*	*Building and programming molecular computers*	*Biomechanical computers*	*Searching by using Sqrt (NOT)*	*Reconfigurable computers*
	SLO-2	*Digital signals and gates*	*Optical computing- Introduction*	*Bioelectronic computers*	*Hardware challenges to large Quantum Computers*	*Teramac concept as a prototype*
S-6	SLO-1	*Silicon nanoelectronics-short channel effects*	*Current use of optics for computing*	*Engineering biocomputers*	*Ion traps-Solids*	*Soft computing*

	SLO-2	*Leakage current in scaled devices-process variation*	*Advantages of optical methods over electronic ones*	*DNA computer*	*NMR in organic liquids-Optics*	*Methods of soft computing -Fuzzy systems*
S-7	SLO-1	*Carbon nanotube electronics*	*Some roles of optics – 2D array mapping*	*Information processing with chemical reactions*	*Fabrication Challenges*	*Evolutionary algorithms*
	SLO-2	*Band structure of carbon nanotubes-Carbon Nanotube properties*	*Garbage free operations*	*Peptide computing*	*Testing and architectural challenges*	*Connectionistic systems*
S-8	SLO-1	*Carbon nanotube field effect transistors*	*Optical computing paradigms*	*Development of a peptide computer*	*Quantum dot cellular automata*	*Computational Intelligence systems*
	SLO-2	*Simulation of Schottky barrier carbon nanotube FETs*	*Ultrafast pulse shaping -Tb/sec data speeds*	*Nanomachines*	*Computing with QCA*	*Characteristics of neural networks in nanoelectronics*
S-9	SLO-1	*MOSFET like carbon nanotube FETs*	*Role of non-linear materials in Nanocomputing: Need for new materials*	*Wetware computer*	*QCA clocking*	*Local processing*
	SLO-2	*Simulation of MOSFET characteristics*	*Advance in Photonic switches*	*Parallel processing*	*QCA design rules*	*Self organization*

Learning Resources	1. *Vishal Sahni and Debabrata Goswami, "Nanocomputing: The Future of Computing", Tata McGraw-Hill Education, 2008*	2. *Karl Goser, Peter Glösekötter and Jan Dienstuhl, "Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum devices", 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. Hemant Dixit, Global Foundaries,USA, aplahemant@gmail.com	*1. Dr. Ranjit Kumar Nanda, IIT Madras, nandab@iitm.ac.in*	*1. Dr. V. J. Surya, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. G. P. Das,IIT Kharagpur gpdas@metal.iitkgp.ac.in*	*2. Dr. Saurabh Ghosh, SRMIST*

Course Code	18NTO308T	Course Name	SMART SENSOR SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire knowledge on various sensor systems*
CLR-2 :	*Understand different conversion phenomena involved in sensors*
CLR-3 :	*Describe construction and function of different sensors*
CLR-4 :	*Gain knowledge on the material requirement for different sensing mechanisms*
CLR-5 :	*Gain knowledge on individual sensing devices and integration of technologies*
CLR-6 :	*Understand the basic requirements of basic microsystem technologies and MEMS fabrication processes*

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 principles involved in conversion from one energy domain to electrical signal*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyze the sensor characteristics and its suitability for a particular application*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Utilize the suitable material properties to design a sensor*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Implement a suitable sensor technology for a particular application*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Explain the concepts of system organization and integration to make a smart sensor*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Utilize the different sensor concepts to design a lab-on-chip*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definitions of Sensors and Smart Sensors*	*Acoustic waves: Fundamentals*	*Light Detectors*	*Biosensors definition*	*Fundamentals of MEMS/ fabrication:*
	SLO-2	*Integrated Smart Sensors and Applications*	*Piezoelectric materials for acoustic sensors*	*Photodiodes, Photoresistors*	*Bioreceptors*	*Frequently Used Microfabrication Processes*
S-2	SLO-1	*Sensors classifications*	*Solid state SAW sensors*	*HgCdTe infrared sensors*	*Construction of different biosensors*	*Lithography, thin film deposition*
	SLO-2	*Detection means used in sensors and conversion phenomena*	*Applications of SAW sensors*	*Visible-light color sensors, high-energy photodiodes*	*Immobilization of biological elements*	*Oxidation, Etching (wet and dry)*
S-3	SLO-1	*Measurements*	*Acoustic Sensors: Resistive Microphones, Condenser Microphones*	*Radiation Detectors: Scintillating Detectors*	*Transduction principles used in biosensing*	*MEMS fabrication technologies: Bulk micromachining and structures*
	SLO-2	*Units of Measurements*	*Piezoelectric Microphones*	*Semiconductor Radiation Detectors*	*Lab-on-chip/Microsystems/MicroTAS*	*Surface micromachining and structures*
S-4	SLO-1	*Sensor Characteristics: Transfer Function, Calibration, Static Characteristics*	*Magnetic sensors*	*Thermal Sensors: Functional Principle*	*Microfluidics*	*High-aspect-ratio technology microfluidics microsystem components*
	SLO-2	*Accuracy, Calibration Error, Hysteresis, Nonlinearity, Resolution, Dynamic Characteristics*	*Magnetic Effects and materials*	*Heat Transfer Mechanisms*	*Microfluidic unit operations*	*LIGA(Lithographie, Galvanoformung, Abformung)*
S-5	SLO-1	*Physical principles of sensing: electric charges*	*Integrated Hall sensors*	*Temperature Sensors*	*Microsystem Integration*	*Microsystem components*
	SLO-2	*Electric fields, and potentials*	*Magnetotransistors*	*Thermoresistive Sensors*	*System organization and functions*	*Application of different Microsystem components*
S-6	SLO-1	*Capacitance, dielectric constant*	*Force, Strain, and Tactile Sensors*	*Thermoelectric Contact Sensors, Thermocouple Assemblies*	*Interface electronics*	*Nanotechnology:*
	SLO-2	*Magnetic Principle*	*Strain Gauges, Piezoelectric Force Sensors*	*Semiconductor pn-Junction thermal Sensors, Optical Temperature Sensors*	*Fundamentals of interfacing*	*product prospects - application trends*
S-7	SLO-1	*Induction Principle*	*Tactile Sensors*	*Chemical sensors: Classes of Chemical*	*Universal transducer interface*	*Ultra-thin films*

				Sensors		
	SLO-2	*Electrical Resistance*	*Piezoresistive sensors(Tactile)*	*Interaction of gaseous species at semiconductor Surfaces*	*Three-Signal Technique*	*Making of ultrathin films*
S-8	SLO-1	*Piezoelectric effect*	*Piezoelectric Sensors(Tactile)*	*Catalysis, the acceleration of chemical reactions,*	*Introduction to microsystems engineering*	*Creation of lateral nanostructures,*
	SLO-2	*Pyroelectric effect*	*Capacitive Touch Sensors (Tactile)*	*Thin-film sensors (Chemoresistive sensors)*	*Microtechnologies*	*Creation of clusters and nanocrystalline materials*
S-9	SLO-1	*Hall effect Principle*	*PiezoresistivePressure Sensors*	*Filed Effect Transistor for Gas sensing*	*Systems development: methods and tools*	*Principles of self-organization*
	SLO-2	*Seebeck and Peltier effects*	*Capacitive Pressure Sensor*	*FET devices ion sensing*	*Constructive and connective techniques*	*Future trends*

Learning Resources	1. *Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs, and Applications", Springer; 4th ed. 2010* 2. *S. M. Sze, "Semiconductor Sensors", Wiley-Interscience,1994*	3. *Gerard Meijer, "Smart sensor systems", Wiley, 2008* 4. *W Gopel, J. Hesse, J. N. Zemel, "Sensors A Comprehensive Survey" Vol. 8, Wiley-VCH, 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. N. Vijayan, CSIR-NPL, nvijayan@nplindia.org	*1. Prof. S. Balakumar, University of Madras, balakumar@unom.ac.in*	*1. Dr. A. Karthigeyan, SRMIST*
2. Dr. Krishna SurendraMuvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Prof. V. Subramaniyam, IIT Madras, manianvs@iitm.ac.in*	*2. Dr. M.Kiran, SRMIST*

Course Code	18NTO401T	Course Name	2D MATERIALS AND APPLICATIONS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Nanotechnology	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 graphene and its superior physical properties*			
CLR-2 :	*Gain the knowledge on other emerging semiconducting and insulating layered materials*			
CLR-3 :	*Describe the methods on synthesis of 2D materials*			
CLR-4 :	*Understand the 2D materials physical properties using micro and nanocharacterization techniques*			
CLR-5 :	*Gain knowledge on applications 2D materials in technological applications*			
CLR-6 :	*Understand the importance of 2D materials applications real life 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 :	*Understand the scientific knowledge on producing graphene*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyze different 2D materials with tunable properties*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Different methods of synthesis method for 2D materials*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Utilize the spectroscopic concepts to analyze the properties of materials*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Use the 2D materials for Biomedical applications*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Use the 2D materials for optoelectronics and nanoelectronics*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Carbon Atom and Its Allotropes*	*Graphene derivatives: Graphene Oxide*	*Synthesis of 2D materials*	*Applications of 2D materials*	*Graphene-based transistors*
	SLO-2	*Diamond, Graphite, Fullerenes*	*Graphene composites*	*Bottom up methods*	*Biomedical applications of rGO*	*Graphene based RF transistors for Flexible electronics*
S-2	SLO-1	*Graphene*	*Beyond graphene*	*Chemical Vapor Deposition*	*Drug/gene delivery,bioimaging, biosensing*	*2D TMD based Photodetectors*
	SLO-2	*Electronic Structure of graphene*	*Transition metal dichalcogenide (TMD) and white graphene(White graphene)*	*Pulsed Laser Deposition*	*Photothermal therapy*	*Phototransistors*
S-3	SLO-1	*Electronic properties*	*Crystal structure*	*Epitaxial growth*	*Tissue engineering and anti-bacterial applications*	*Hybrid Phototransistors*
	SLO-2	*Optical properties*	*Electronic and optical properties*	*Physical vapor deposition*	*Biocompatibility and biodistribution*	*Heterostructure Photodetectors*
S-4	SLO-1	*Helicity and Chirality*	*Traps and defects*	*Top down methods*	*Scaffolds for tissue engineering*	*2D TMD based Light Emitters*
	SLO-2	*Klein Tunneling*	*Mechanical properties*	*Mechanical Exfoliation*	*Cancer therapy*	*Hot Carrier EL*
S-5	SLO-1	*High Mobility of graphene*	*Strain effect on electrical and vibrational properties*	*Liquid phase exfoliation*	*Graphene devices for Biomolecule detection*	*Light-Emitting Diodes*
	SLO-2	*Minimum Conductivity and Universal Optical Conductivity of graphene*	*Theoretical methods*	*Electrochemical Lithium Intercalation*	*Graphene devices for Biomolecule sequencing*	*Circularly Polarized Light Emission*
S-6	SLO-1	*Bilayer and multilayer Graphene*	*Silicene and Germanene*	*Ball Milling*	*Photocatalysts*	*Heterostructure Light Emitters*
	SLO-2	*Presence of a Magnetic Field*	*Properties of Silicene and Germanene*	*Hydrodynamics Exfoliation*	*Graphene oxide (GO) forDye degradation and pollutant adsorption*	*2D TMD-Based Photovoltaics applications :*
S-7	SLO-1	*Homogeneous Magnetic Field*	*2D Topological Insulator*	*Basic Characterization of 2D materials*	*Hydrogen production form water splitting*	*Solar cells*
	SLO-2	*LLs in Bilayer Graphene*	*Phosphorene: A Novel 2D Material*	*UV-Vis absorption Spectroscopy*	*TMDs 2D materials for Electrocatalysis and electrochemical sensing*	*Graphene membranes*
S-8	SLO-1	*Anomalous Quantum Hall Effect*	*2D Crystal-Based Heterostructures*	*Raman spectroscopy*	*Oxygen evolution reaction (OER)*	*Membranes for separation*
	SLO-2	*Carrier density*	*A 'Legoland' of Two-Dimensional Materials*	*Scanning electron microscopy*	*Oxygen reduction reaction (ORR)*	*Membranes as barriers*

S-9	SLO-1	*Gauge Fields Induced by Lattice Deformation*	*Handling of 2D Heterostructures: Practical Issues*	*Transmission electron microscopy*	*Hydrogen evolution reaction (HER)*	*Supercapacitor electrodes*
	SLO-2	*Deformation and Elastic strain*	*Tunnel Diodes and Transistors Based on 2D Heterostructures*	*Atomic force microscopy*	*Hydrogen oxidation reaction (HOR)*	*2D Black phosphorus based FET for Sensor and detector applications*

Learning Resources	1. *Banks, Craig E., and Dale AC Brownson, eds. "2D Materials: Characterization, Production and Applications"- CRC Press, 2018.* 2. *Houssa, Michel, Athanasios Dimoulas, and Alessandro Molle,"2D Materials for Nanoelectronics"- CRC Press, 2016.*	3. *Tiwari, Ashutosh, and Mikael Syväjärvi, eds. "Advanced 2D Materials" - John Wiley & Sons, 2016.* 4. *Dragoman, Mircea, and Daniela Dragoman,"2D Nanoelectronics: Physics and Devices of Atomically Thin Materials"- Springer, 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. Hemant Dixit, GlobalFoundaries,USA, aplahemant@gmail.com	*1. Dr. Ramaprabhu, IIT Madras, ramp@iitm.ac.in*	*1. Dr.V.Eswaraiah, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. Abhay, SRM IST*

Course Code	18NTO402T	Course Name	NANO AND MICRO ELECTROMECHANICAL SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Nanotechnology	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 :	*Acquire knowledge on MEMS and NEMS fundamentals*																		
CLR-2 :	*Understand different principles involved in MEMS devices*																		
CLR-3 :	*Describe construction and function of MEMS actuators*																		
CLR-4 :	*Gain knowledge on the material requirement for different actuation mechanisms*																		
CLR-5 :	*Gain knowledge on individual sensing and Micromechanical components and their integration*																		
CLR-6 :	*Understand the basic microsystem and MEMS fabrication process technologies*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Apply the principles of sensing and actuation to design NEMS and MEMS devices*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyze the suitability of a actuation mechanism for a particular application*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Utilize the suitable material properties to design a MEMS structure*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply a suitable microsystem technology to create different nano and micro mechanical structure*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-5 :	*Design high aspect ratio structure and integration with microsystem technologies*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Utilize the different sensing and actuation concepts to design a lab-on-chip*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Micro- and nanoelectromechanical systems*	*Photolithography*	*SensingPrinciples*	*Magnetic materials used in MEMS*	*Principles of MOEMS technology*
	SLO-2	*MEMS and NEMS: An overview*	*Structural and sacrificial materials*	*Actuation Principles*	*MagneticProperties used in MEMS*	*Applications of MOEMS*
S-2	SLO-1	*Nanoelectromechanical Systems*	*Thin film deposition*	*Components: Beam*	*Magnetic sensing and detection*	*Properties of Light*
	SLO-2	*Scaling Laws*	*Physical Vapor Deposition , Chemical Vapor Deposition techniques*	*Cantilever, microplates*	*Magneto resistive sensor*	*Light modulators*
S-3	SLO-1	*Modeling*	*Impurity doping*	*Capacitive effects*	*Hall Effect based sensors*	*Beam splitters*
	SLO-2	*The input-output concept*	*Etching (Wet and Dry)*	*Piezo elements*	*Magnetodiodes, Magntotransistor*	*Micro lens*
S-4	SLO-1	*Sensors and Actuators*	*Bulk micromachining*	*Strain Measurements*	*Magnetic actuation Principles*	*Micro mirror,Digital micromirror device*
	SLO-2	*Energy Domains and Transducers*	*Surface micromachining*	*Pressure and flow measurements*	*Essential magnetic actuation concepts*	*Optical switch, Wave guide and tuning*
S-5	SLO-1	*Sensors considerations*	*Wafer bonding*	*MEMS Gyroscopes*	*Magnetic MEMS actuators*	*Properties of fluid*
	SLO-2	*Actuator considerations*	*Lithographie, Galvanoformung, Abformung (LIGA) Process*	*Shear modepiezo actuators*	*Bidirectional Microactuators*	*Fluid actuation methods*
S-6	SLO-1	*Mechanical MEMS*	*MEMS Integration*	*Gripping piezo actuators*	*RF based communication systems*	*Dilectrophoresis, Electrothermal flow*
	SLO-2	*Thermal MEMS*	*Packaging considerations*	*Strain Measurement*	*RF MEMS*	*thermo capillary effect*
S-7	SLO-1	*Micro-Opto-Electro-Mechanical Systems (MOEMS)*	*Basic Modeling elements: Mechanical*	*Thermal sensors and actuators*	*MEMS inductor*	*Micropumps: design consideration*
	SLO-2	*Magnetic MEMS, Radio-Frequency MEMS*	*Basic Modeling elements: Electrical systems*	*Thermal basics*	*MEMS Varactors*	*Lab-on-chip*
S-8	SLO-1	*Microfluidic systems*	*Basic Modeling elements: Fluid systems*	*Thermocouples*	*MEMS Tuner/filter*	*IC technology*
	SLO-2	*Bio-Chemo devices*	*Basic Modeling elements: Thermal systems*	*Thermoresistors*	*MEMS Resonators*	*MEMS Fabrication versus IC fabrication*
S-9	SLO-1	*MEMS Architectures*	*Translational pure mechanical systems*	*Actuators based on thermal expansion*	*MEMS Switches*	*IntegratingIC and MEMS*
	SLO-2	*NEMS Architectures*	*Rotational pure mechanical systems*	*Applications of thermal actuators*	*MEMS Phase shifter*	*Future prospects*

Learning Resources	1. *Mahalik N P, "MEMS", Tata McGraw-Hill Education, 2008* 2. *Sergey Edward Lyshevski, "Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering", CRC Press, 2005*	3. *Chang Liu "Foundation of MEMS", Prentice Hall, 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. N. Vijayan, CSIR-NPL, nvijayan@nplindia.org	*1. Prof. S. Balakumar, University of Madras, balakumar@unom.ac.in*	*1. Dr. A. Karthigeyan, SRMIST*
2. Dr. Krishna Surendra Muvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. M. Kiran, SRMIST*

Course Code	18NTO403T	Course Name	SCIENTIFIC RESEARCH PRINCIPLES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Familiarize with the concept of research ethics*
CLR-2 :	*Understand the concept of academic plagiarism*
CLR-3 :	*Understand the concept of Good, Bad science and pseudoscience*
CLR-4 :	*Gain knowledge on research methodology*
CLR-5 :	*Learn the process of scientific writing*
CLR-6 :	*Understand the principles of research Design*

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 scientific concepts of ethics and plagiarism*	*2*	*80*	*80*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Acquire the knowledge of global and national research ethics*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Ability to appreciate the importance of honesty and integrity in academic life*	*2*	*80*	*80*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Apply scientific research methodology for real life problems*	*2*	*75*	*70*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Utilize the method of scientific writing*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Utilize the methods of data analysis in various applications*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction – ethics*	*Research and ethics*	*Good science vs. Bad science*	*Research design*	*Scientific Writing*
	SLO-2	*Scientific ethics*	*Scientific misconduct*	*Pseudoscience*	*Design of the apparatus*	*Authenticity, accuracy*
S-2	SLO-1	*Code of ethics*	*Forms of misconduct*	*Ways of identification*	*Design issues and remedies*	*Originality of the work*
	SLO-2	*Ethics for Engineering*	*Cheating*	*Curiosity and research*	*Design methodology*	*Title preparation*
S-3	SLO-1	*Standards of ethical conduct*	*Plagiarism*	*Empiricism*	*Experimentation – sampling*	*List of authors and addresses*
	SLO-2	*Ethical conduct-expectations and outcome*	*Recognizing plagiarism*	*Rationalism*	*Experimentation –measurements*	*Abstract writing*
S-4	SLO-1	*National research ethics*	*Self-plagiarism*	*Intuition, authority*	*Replication of the data*	*introduction writing*
	SLO-2	*Global research ethics*	*Ghostwriting and detection*	*Literature review*	*Data analysis*	*Description of methods*
S-5	SLO-1	*Intellectual property rights*	*Honor code system*	*Elementary scientific methods*	*Error identification*	*Description of methodology*
	SLO-2	*Fundamental IP laws*	*academic dishonesty*	*Observations and observational bias*	*Error in measurement*	*Measurements*
S-6	SLO-1	*Patent and copy rights*	*Prejudice*	*Problem identification*	*Classification of errors*	*Description and types of measurements*
	SLO-2	*Authorship and credit*	*Intuition*	*Basic assumptions*	*Errors analysis*	*Analysis of results*
S-7	SLO-1	*Conflict of interest*	*Observation bias*	*Hypothesis*	*Interpretation of the data*	*Explanation of results*
	SLO-2	*Error and negligence*	*Self-misunderstanding*	*Formulation of an hypothesis*	*Test of the hypothesis*	*Result and analysis*
S-8	SLO-1	*Case studies – cloning scandal, miracle drug thalidomide*	*Egoism*	*Hypothesis driven research design*	*Mathematical modeling*	*Discussion and acknowledgement*
	SLO-2	*Case studies –, miracle drug thalidomide*	*Some plagiarism cases in India*	*Verification of Hypothesis*	*Types of mathematical modeling*	*Conflict of interest declaration*
S-9	SLO-1	*Jan HendrikSchön case*	*Recent Plagiarism cases (abroad)*	*Identification of experimental techniques*	*Numerical computation*	*References, paper/poster presentation*
	SLO-2	*The Baltimore affair*	*Consequence of Plagiarism*	*Implementation of the experimental techniques*	*Result presentation*	*Electronic publication*

Learning Resources	
	1. *National academy of Science, National academy of Engineering, and Institute of Medicine, "On being a scientist: A guide to responsible conduct in research", Third edition, The National Academics Press, 2009*
	2. *Adam Briggle and Carl Mitcham, "Ethics and science: An Introduction", Cambridge University Press, 2012*
	3. *David B. Resnik, "The ethics of science: An introduction", Routledge Publication, 1998*
	4. *Gary Comstock, "Research Ethics: A philosophical guide to the responsible conduct of Research" Cambridge University Press, 2013*

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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. Narayanasvamy Vijayan, National Physical Laboratory, nvijayan@nplindia.org	*1. Prof. V. Subramaniam, IITM, Chennai, manianvs@iitm.ac.in*	*1. Dr. A. Karthigeyan, SRMIST*
2. Dr.A. Pandikumar, Scientist, CSIR-CERL, pandikumar@cecri.res.in	*2. Prof. D. Arivuoli, Anna University, arivuoli@annauniv.edu*	*2. Dr. A. A. Alagirisamy, SRMIST*

Course Code	18NTO404T	Course Name	MICRO AND NANOFLUIDIC TECHNOLOGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the theory of fluidics in a micro scale*
CLR-2 :	*Gain knowledge in micro fluidics equations*
CLR-3 :	*Understand the concept behind viscous flow in micro scale*
CLR-4 :	*Acquire the knowledge in Micro fluidic devices and manufacturing*
CLR-5 :	*Gain knowledge scaling materials for manufacturing*
CLR-6 :	*Understand the sensors for micro fluidic 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 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 concept of fluidics in micro and nanoscale*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Analyze the flow and viscosity of the fluidics*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Analyze the viscous flow of micro/nano fluidic devices*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Utilize the knowledge gained for designing micro/nano fluidic devices*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Apply the various fluidic equations to design micro/nano fluidic devices*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Design micro/nano fluidic devices based on theory*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction: Fundamentals of kinetic theory*	*Micro and nanofluids – An Introduction*	*Introduction to Microscale Viscous Flow*	*Introduction - concepts microfluidic devices*	*Introduction to Electro chemistry*
	SLO-2	*Fundamentals of molecular models*	*Basic concepts in microfluidics & Nanoscale fluidics*	*Structure of flow in a pipe or channel*	*Microfluidic Technology*	*Electrical double layer*
S-2	SLO-1	*Kinetic theory of micro and macroscopic properties*	*Governing equations*	*Posiseuille's equation*	*Fabrication Of A Simple Microfluidic Chip*	*Electro-chemical potential*
	SLO-2	*Molecular models of micro and macroscopic properties*	*Applications- Preparatory concepts*	*Posiseuille flow in a pipe*	*Advantages of microfluidic devices*	*Chemical potential-acid and base*
S-3	SLO-1	*Binary collisions*	*Laws of fluid flows determination of transport properties*	*Velocity in slip flow of gases*	*Fluidic transport mechanisms In Microfluidic Devices*	*Electrolyte & electrical conductivity*
	SLO-2	*Distribution functions*	*Classification of fluid flow*	*Velocity in slip flow of liquids*	*Pressure-driven and electro-kinetically driven flows in Devices*	*Semi-permeable membrane*
S-4	SLO-1	*Boltzmann equation*	*Continuum approximation*	*Theory of flow in a thin film under gravity*	*Scaling of materials*	*Micro and nanofluidics devices*
	SLO-2	*Maxwellian distribution functions*	*Limitations and drawbacks*	*Two and three dimensional approach*	*Silicon materials for the manufacture*	*Applications in different fields*
S-5	SLO-1	*Wall slip effects*	*Kinematics of Microscale Liquid Flow*	*Derivation - thin film under gravity*	*Glass materials for the manufacture*	*Fabrication and design of microfluid device*
	SLO-2	*Accommodation coefficients*	*Derivation of Kinematics of Microscale Liquid Flow*	*Properties of thin film equation*	*Polymers materials for the manufacture*	*Testing of microfluid device*
S-6	SLO-1	*Flow and heat transfer analysis of microscale*	*Liquid flow along surface*	*Developing suction and laminar flows*	*Fluidic structures*	*DNA transport*
	SLO-2	*Couette flows*	*Effect of body forces in liquid flow*	*Flow control*	*Manufacturing a fluidic structure*	*Development of artificial kidney*
S-7	SLO-1	*Pressure driven gas micro- flows*	*Navier- Stokes equation*	*Surface tension driven flow*	*Stacking sequence*	*Electrochemical sensing*
	SLO-2	*Micro flows with wall slip effects*	*Equation's properties*	*And its limitations*	*Stacking - fabrication methods*	*Electrochemical Micro/Nao fluidic devices*
S-8	SLO-1	*Concept of Heat transfer in micro-Poiseuille flows*	*Theory of Two-dimensional Navier- Stokes equation*	*Sedimentation of a solid particle*	*Surface modifications*	*Receptor and Transducer based classification of biosensors*
	SLO-2	*Expression for Poiseuille flows*	*Two-dimensional Navier- Stokes equation*	*Transportation of a solid particle*	*Different techniques involved in Surface*	*Types of Biotransducers*

			in terms of Reynolds Equation		*modifications*	
S-9	SLO-1	*Mechanism of micro flows under compression*	*Navier- Stokes equation for Steady and compressible flow*	*Simple model for blood flow*	*Spotting mechanisms*	*Nanopores and nanopore membrane for biochemical sensing*
	SLO-2	*Compressibility and its effects*	*Steady and incompressible flow Navier-Stokes equation*	*Non-Newtonian properties of blood*	*Detection mechanisms*	*Single Molecule sensing devices*

Learning Resources	1. *Terrence Conlisk, "Essential of Micro and nanofluidics: with applications to biological and chemical sciences", Cambridge University Press, 2012* 2. *Joshua Edel, "Nanofluidics", RCS publishing, 2009*	3. *HenrikBruus, "Theoretical Microfluidics", Oxford Master Series in Physics,2007* 4. *PatricTabeling, "Introduction to Microfluids", Oxford U. 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. Nagesh Kini,Thermax,Pune,Maharastra,nagesh.kini@gmail.com	*1. Dr. Sampath Kumar T.S, IIT Madras, tssk@iitm.ac.in*	*1. Dr. V. Eswaraiah, SRMIST*
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Course Code	18NTO405T	Course Name	THIN FILM PHOTOVOLTAICS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Nanotechnology	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 :	*Review the basic principles and design of photovoltaic cell technology*			
CLR-2 :	*Understand the key properties of semiconductors films used in photovoltaic technology*			
CLR-3 :	*Review the basic photovoltaic device structure and design*			
CLR-4 :	*Develop an understanding of different thin film photovoltaic device technologies and their design*			
CLR-5 :	*Gain exposure to the various tools and techniques used in thin film photovoltaics*			
CLR-6 :	*Acquire knowledge on advanced concepts explored in thin film photovoltaics*			

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 :	*Differentiate between different types of photovoltaic technologies*	*2*	*80*	*75*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-2 :	*Interpret important properties of semiconductors relevant to thin film photovoltaics*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
CLO-3 :	*Apply different photovoltaic device design concepts for different applications*	*2*	*75*	*70*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
CLO-4 :	*Appreciate advancement of different types of thin film solar cells*	*2*	*80*	*75*	*M*	*H*	*H*	*M*	*H*	*H*	*H*	*H*	*H*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-5 :	*Appreciate the advanced concepts and explorations in thin film photovoltaics*	*2*	*80*	*70*	*H*	*M*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*H*	*M*	*H*	*H*	*H*	*H*
CLO-6 :	*Perform thin film photovoltaic device fabrication, testing and calculations*	*2*	*80*	*75*	*H*	*M*	*M*	*H*	*H*	*M*	*M*	*H*	*H*	*H*	*M*	*H*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics and basic components of PV systems*	*Semiconductor thin films-Optical absorption*	*Different generations of PV*	*Thin film deposition*	*Device architectures*
	SLO-2	*Mechanism of PV*	*Carrier photo generation*	*Thin film solar cells*	*Various techniques*	*Flexible substrates, transparent devices.*
S-2	SLO-1	*Sun as a source of energy*	*Band gap*	*Silicon solar cells*	*Evaporation techniques*	*Multi-junctions*
	SLO-2	*Solar spectrum , air mass*	*Direct Vs Indirect bandgaps*	*Thin film Silicon solar cells*	*Sputtering techniques*	*Tandem solar cells*
S-3	SLO-1	*Solar Cell parameters*	*Carriers*	*Amorphous Silicon based solar cells*	*MBE*	*Bandgap profile optimization*
	SLO-2	*Device testing*	*Carriers transport*	*a-Si and a-Si: H solar cells*	*Laser based techniques*	*Solar spectrum matching*
S-4	SLO-1	*Efficiency measurements*	*Minority carrier transport properties*	*II–VI thin film PV*	*CVD, PECVD*	*Light trapping*
	SLO-2	*FF, V_{OC}, J_{SC} etc for ideal cells*	*Carrier recombination–lifetime and defects*	*Chalcopyrite photovoltaics*	*Spray and Non vacuum routes*	*Antireflection coatings*
S-5	SLO-1	*Non-idealities, Loss mechanisms*	*Band to band and Shockley–Read–hall recombination*	*CdTe/CdS thin film solar cells*	*Techniques to measure thickness*	*Self-cleaning coatings*
	SLO-2	*Optical & electrical loss mechanisms*	*High injection effects*	*Superstrate structure*	*Optical and electronic properties of thin films*	*Plasmonic enhancements*
S-6	SLO-1	*Basics of solar cell device design*	*Surface and interface recombination*	*CuInGaSe2/CdS thin film cell technologies*	*Fabrication process of thin film solar cells*	*Luminescence concentrators*
	SLO-2	*Minimization of losses*	*Implications on device performance*	*Earth abundant alternatives*	*Specific techniques used*	*Up conversion*
S-7	SLO-1	*Lateral design*	*PN homojunctions*	*Thin film solar cells based on Cu2ZnSnS4*	*Established parameters in thin film cell technologies*	*New concepts*
	SLO-2	*Vertical design*	*Carrier transport under broad spectrum illumination*	*other materials*	*Basic characterization tools*	*quantum dots, & wires,*
S-8	SLO-1	*Optical versus electrical tradeoffs*	*Photocurrent and Spectral response*	*3rd generation thin film solar cells: DSSCs*	*Advanced characterization methods for device quality & defects*	*Intermediate band solar cells*
	SLO-2	*Optimization*	*Ideal diodes*	*QDSSCs, heterojunctions*	*Study of interfaces, recombination etc*	*Multiple exciton generation, hot carrier solar cells*

S-9	SLO-1	*Examples of semiconductors in PV*	*Real p-n diodes*	*3rd generation thin film solar cells: organic PV*	*Basics of device modelling*	*Commercial status*
	SLO-2	*Device types in PV*	*Temperature effects*	*Hybrid, perovskite solar cells etc.*	*Simulation softwares*	*Hopes and challenges for thin film PV*

Learning Resources	1. *Solanki C.S., "Solar photovoltaics - fundamentals, technologies and applications", 3rd edition, PHI LearningPvt Ltd, New Delhi, India* 2. *Fonash S.J., "Solar Cell Device Physics", Academic, 2010* 3. *Moller H.J., "Semiconductors for Solar Cells",Artech House, 1993*	4. *Green M.A., "Third Generation Photovoltaics: Advanced Solar Energy Conversion", Springer, 2006Fundamentals of Solid State Engineering, Manijeh Razeghi, KLUWER ACADEMIC PUBLISHERS, 2002* 5. *Rointan. F, Bunshah," Hand Book of Deposition technologies for Thin Films and coatings by Science, Technology and Applications" ,Second Edition , Noyes Publications, 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18NTO406T	Course Name	NANOTECHNOLOGY IN SOCIETAL DEVELOPMENT	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Department of Physics and Nanotechnology	Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an insight into the fundamentals of social-economic implications of nanotechnology*
CLR-2 :	*Provide an insight into the fundamentals of ethical implications of nanotechnology*
CLR-3 :	*Understand the legal risks related with the nanotechnology*
CLR-4 :	*Understand the implications of nanotechnology in quality of life*
CLR-5 :	*Understand the problems of governance of nanotechnology*
CLR-6 :	*Explore the matters related to patents associated with nanotechnology*

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 :	*Address the socioeconomic implications of nanotechnology*	2	80	75	M	H	M	H	M	H	H	H	H	H	M	H	H	H	H
CLO-2 :	*Apply the knowledge of ethical implications pertaining to nanotechnology*	2	80	70	M	H	M	H	M	H	H	H	H	H	M	H	M	M	M
CLO-3 :	*Address the legal risks related with the nanotechnology*	2	75	70	M	M	M	H	M	H	H	M	H	H	M	H	H	H	H
CLO-4 :	*Improve the quality of life*	2	80	75	H	H	M	H	M	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Handle the issues related to patents associated with nanotechnology*	2	80	70	M	M	H	H	M	M	M	H	M	H	H	H	H	H	H
CLO-6 :	*Address the problems of governance of nanotechnology*	2	80	75	M	M	M	H	M	H	H	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Knowledge and Scientific Understanding of Nature*	*National Nanotechnology Initiative*	*Nanotechnology, Education, and the Fear of Nanobots*	*Societal Implications of Nanotechnology (*	*Public Perceptions of Nanotechnology*
	SLO-2	*Industrial Manufacturing, Materials and Products*	*The Age of Transitions*	*Mathematical Challenges in Nanoscience and Nanotechnology*	*Socio-economic Research on Nanoscale Science and Technology: A European Overview and Illustration*	*Public Awareness of Nanotechnology*
S-2	SLO-1	*Medicine and the Human Body*	*Technological Implications of Nanotechnology: Why the Future Needs Us*	*Implications of Nanotechnology for the Workforce*	*Nanotechnology and Unintended Consequences*	*Public interaction research*
	SLO-2	*Sustainability: Agriculture, Water, Energy, Materials, and Clean Environment*	*Don't Count Society Out - A Response to Bill Joy*	*Societal Impacts of Nanotechnology in Education and Medicine*	*A Cultural Ecology of Nanotechnology*	*Nanotechnological risks*
S-3	SLO-1	*Space Exploration*	*National Needs Drivers for Nanotechnology*	*Technological and Educational Implications of Nanotechnology: Infrastructural and Educational Needs*	*Envisioning and Communicating Nanotechnology to the Public*	*Assessment of Nanotechnological risks*
	SLO-2	*National Security*	*Nanotechnology and Societal Transformation*	*Dynamics of the Emerging Field of Nanoscience*	*Vision, innovation, and policy*	*Importance of Risk communication*
S-4	SLO-1	*Moving into the Market*	*Focus on Economic and Political Implications of Potential Technology*	*Focus on Medical, Environmental, Space Exploration and National Security Implications*	*Challenges for government and universities*	*Problems in Risk communication*
	SLO-2	*The Interactive Process of Innovation and Diffusion*	*Impact of Nanotechnology on the Chemical and Automotive Industries*	*Challenges and Vision for Nanoscience and Nanotechnology in Medicine: Cancer as a Model*	*Environmental Impacts of Nanomaterials*	*Nanotechnology's social impacts*
S-5	SLO-1	*Unintended and Second-order Consequences*	*Information Technology Based on a Mature Nanotechnology: Some Societal Implications*	*Nanotechnology in Medicine*	*Nanoparticle Toxicity and risk*	*A preliminary analysis of nanotechnology in the media*
	SLO-2	*Ethical Issues and Public Involvement in Decision Making*	*Societal Implications of Scaling to Nanoelectronics*	*Lifecycle/Sustainability Implications of Nanotechnology*	*Social impacts of nano biotechnology issues*	*Nanoscience and engineering - Public engagement*

S-6	SLO-1	*Education of Nanoscientists, Nanotechnologists, and Nanofabrication Technicians*	*Future Implications of Nanoscale Science and Technology: Wired Humans, Quantum Legos, and an Ocean of Information*	*Implications of Nanotechnology for Space Exploration*	*Problems of governance of nanotechnology*	*Nanophobia – Fear of Nanotechnology*
	SLO-2	*Education of Social Scientists*	*Implications of Nanotechnology in the Pharmaceutics and Medical Fields*	*Security Aspects of Nanotechnology*	*Negotiations over quality of life in the nanotechnology initiative. Governance*	*Public Engagement with nanotechnology*
S-7	SLO-1	*Social Science Research Approaches and Methodologies*	*We've Only Just Begun*	*Focus on Social, Ethical, Legal, and Cultural Implications*	*Technological revolutions and the limits of ethics in an age of commercialization*	*Nanotechnology: moving beyond risk*
	SLO-2	*Institutional Infrastructure for Societal Implications Research*	*An Economist Õs Approach to Analyzing the Societal Impacts of Nanoscience and Nanotechnology*	*Social Science Research Methods for Assessing Societal Implications of Nanotechnology*	*Regulatory structures and society*	*Communication streams and nanotechnology: interpretation of a nanotechnology*
S-8	SLO-1	*Other Measures*	*The Strategic Impact of Nanotechnology on the Future of Business and Economics*	*Ethical Issues in Nanotechnology*	*Nanotechnology and social trends*	*Individual perspectives of nanotechnology*
	SLO-2	*Specific Areas for Research and Education Investment*	*Nano-Science and Society: Finding a Social Basis for Science Policy*	*Social Acceptance of Nanotechnology*	*Integrative Technology*	*The case of Cold Fusion*
S-9	SLO-1	*Recommendations to Organizations*	*Focus on Science and Education Implications*	*Social, Ethical and Legal Implications of Nanotechnology*	*Institutionalizing Multi-Disciplinary Engagement*	*The case of Recombinant DNA*
	SLO-2	*With an Eye to the Future*	*Implications of Nanoscience for Knowledge and Understanding*	*Envisioning Life on the Nano-Frontier*	*Nano revolution implications for the artist*	*Historical comparisons - for anticipating public reactions to nanotechnology*

Learning Resources	1. *Mihail C.R., and William S.B., "Nanotechnology: societal implications", Springer publication, 2011 (978-1-4020-5432-7 (e-book))* 2. *Ronald Sandler, "Nanotechnology the Social & Ethical Issues", Woodrow Wilson, 2009*	3. *Mihail C. Roco and William Sims Bainbridge," Societal Implications of Nanoscience and Nanotechnology", National Science Foundation, 2001 (978-0-7923-7178-6)*

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

CLA – 5 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
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Course Code	18NTO407T	Course Name	POLYMER ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire basic knowledge about the structure and property of polymers*
CLR-2 :	*Impart chemistry aspects on various polymer materials*
CLR-3 :	*Acquaint with various compounding ingredients and mixing equipments*
CLR-4 :	*Understand the principles behind the elasticity of the polymers*
CLR-5 :	*Gain knowledge about reinforcements and effect of nanofillers*
CLR-6 :	*Describe rheological behavior with different modifiers*

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 engineering principles underlying the processing of polymer raw materials*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Extend and apply the knowledge of polymers to materials science and engineering*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Identify different fillers as reinforcements*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Illustrate the working of moulding and extrusion techniques*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Evaluate the mechanical behavior of polymers*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Enhance knowledge about the various composite materials*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics and chemistry of polymeric Materials*	*Mechanical behavior of Polymers*	*Polymer Viscoelasticity and Rheology*	*Reinforced Polymers and Composites*	*Elements of Design*
	SLO-2	*Historical developments in polymeric materials*	*Deformation*	*Definition of elastomers*	*Reinforced plastics*	*Engineering thermoplastics*
S-2	SLO-1	*Monomer & functionality*	*Fracture in polymers*	*Requirements of polymer to be elastomer*	*Nanofillers and reinforcements*	*Thermosets and composites*
	SLO-2	*Oligomer*	*Crack growth*	*Nature of viscoelasticity*	*Effect of reinforcements like calcium carbonate, dolomite, silica glass*	*Compression moulds : positive, semi-positive*
S-3	SLO-1	*Polymer structure*	*Tensile strength,*	*Definition of elastomers*	*Fibrous reinforcements (inorganic and organic)*	*Flash mould with horizontal and vertical flash*
	SLO-2	*Methods of synthesis*	*Flexural strength*	*Classifications of elastomers*	*Glass fiber and boron fiber*	*Injection moulds : Two plate and three plates types*
S-4	SLO-1	*Addition polymerization*	*Impact resistance*	*Stress relaxation*	*Carbon fiber and aramide fibers*	*Joining and fastening*
	SLO-2	*Condensation polymerization*	*Percentage elongation*	*Relaxation and retardation times*	*Compression moulding*	*Post extrusion techniques*
S-5	SLO-1	*Co- polymers*	*Griffin theory*	*The time - temperature superposition principle*	*Classification and characteristics of composite materials*	*Metallization*
	SLO-2	*Cross linked polymers*	*Tear test*	*Dynamic properties*	*Fibrous composite materials*	*electroplating*
S-6	SLO-1	*Crosslinking plasticizers and fillers*	*Fatigue and wear*	*Zener model*	*Laminated composite materials*	*Stamping*
	SLO-2	*Crystallinity*	*Hardness*	*Polymer melt viscosity*	*Particulate composite materials*	*Welding and bonding*
S-7	SLO-1	*Glass transition temperature*	*Compressive strength*	*Plasticizers*	*Combinations of composite materials*	*printing and painting on plastics*
	SLO-2	*Degree of polymerization*	*Time dependent properties*	*Lubricants*	*Strength of composites*	*Cross-linking of thermoplastics materials*
S-8	SLO-1	*Classification of polymers*	*Creep*	*Polymer Rheology*	*Failure modes of long, fibre composites*	*Cellular plastics*
	SLO-2	*Molecular weight*	*Effect of weathering*	*Rheological concepts of polymer solutions and melts*	*Axial tensile failure*	*Compound development*
S-9	SLO-1	Molecular weight distribution.	Stress-strain behavior of polymers	Degradation plasticization	Transverse tensile failure, shear failure	Principles of mixing
	SLO-2	Determination of number and average molecular weight	Mechanical behavior of biomedical polymers	Various rheology modifiers	Applications of fiber reinforced polymer composites	Rubbers, designing for strength

Learning Resources	1. *Sperling L.H., Introduction to Physical Polymer Science, Wiley inter science, 4th Edition, 2006* 2. *Mc Crum, Principles of polymer Engineering, 2nd Edition, Oxford, 2001*	3. *HullD., and Clyne W., An Introduction to Composite Materials, Cambridge University Press, 2nd Edition, 1996* 4. *Jones R.M., "Mechanics of Composite Materials", Taylor & Francis, 2nd Edition, 1999*

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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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. Dr. Panka jPoddar, National Chemical Laboratory, p.poddar@ncl.res.in	*1. Dr.G. Arthanareeswaran, NIT Trichy, arthanareeg@gmail.com*	*1. Dr. N. Angeline Little Flower. SRMIST*
2. Dr. P. Sudhakara, CLRI – CSIR, Jalandhar, sudhakarp@clri.res.in	*2. Dr. A. Kannan, IIT Madras, kannan@iitm.ac.in*	*2. Dr. C. Siva, SRMIST*

Course Code	18NTO408T	Course Name	INDUSTRIAL NANOTECHNOLOGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand various nanotechnology techniques and materials from the point of view of the industry*
CLR-2 :	*Understand the practical and business aspects of nanotechnology*
CLR-3 :	*Understand the concept of self-assembly of carbon nanostructures and various other materials and their applications*
CLR-4 :	*Gain knowledge on material in the nanoscale which can be use in Electronics, Medical, Textiles Industry*
CLR-5 :	*Acquire knowledge on physical properties of nanostructured materials and their size and dimensionality dependence*
CLR-6 :	*Acquire knowledge on the measurement techniques at the nanoscale*

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 :	*Elucidate on advantages of nanotechnology based applications in each industry*	2	80	75	H	M	H	H	H	M	M	H	H	H	M	H	H	H	H
CLO-2 :	*Provide instances of contemporary industrial applications of nanotechnology*	2	80	70	H	M	M	H	M	M	M	H	M	H	M	H	M	M	M
CLO-3 :	*Provide an overview of future technological advancements and increasing role of nanotechnology in each industry*	2	75	70	H	M	H	H	H	H	H	M	H	H	H	H	H	H	H
CLO-4 :	*Apply the techniques for fabrication of small-scale devices such as micro/nano electromechanical systems etc.*	2	80	75	M	H	H	M	H	H	H	H	H	H	M	H	H	H	H
CLO-5 :	*Utilize the knowledge on nanomaterial to open a startup company*	2	80	70	H	M	H	H	H	M	M	H	M	H	M	H	H	H	H
CLO-6 :	*Apply the techniques for fabrication of nanofiber on advance textiles Industry*	2	80	75	H	M	M	H	H	M	M	H	H	H	M	H	H	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Nano electrical*	*Nanoparticles in bone substitutes*	*Background of TiO_2 as a semiconductor photocatalyst*	*Applications of nanotechnology in the agriculture*	*Nanotechnology and Nanofibers*
	SLO-2	*Nano electronic devices and its advantages*	*Nanoparticles in dentistry*	*Photocatalytic mechanism and general pathway*	*Agriculture chemicals*	*Nanofibre production –electrospinning*
S-2	SLO-1	*Data storage*	*Tissue engineering*	*Photocatalytic kinetics*	*Nanomaterials in plant protection*	*Basic to Electrospinning: Solution surface tension, Polymer solubility, viscosity*
	SLO-2	*Memory devices*	*Regenerative medicine*	*TiO_2nanoparticles for water purification*	*Diagnosis and control of plant diseases*	*Electrospinning parameters: Controlling morphologies of nanofibers*
S-3	SLO-1	*Micromechanical systems*	*Tissue engineering and nanotechnology*	*Photocatalytic degradation of specific waterborne pollutants*	*Potential of nano-fertilizers*	*Electrospun Polycrylonitrile Nanofibers*
	SLO-2	*Nanoelectromechanical systems*	*Incorporated scaffolds for tissue engineering*	*Nanomaterials in water treatment*	*Nano-fertilizers: Nutritional value and health*	*ElectospunTiC/C composite for energy related application*
S-4	SLO-1	*Lasers*	*Nanorobotics in surgery*	*Origin of arsenic in groundwater, Health impacts of arsenic*	*Applications of nanotechnology in food industry*	*Light-emitting polymer nanofiber*
	SLO-2	*Use of lasers in lighting and displays*	*Role of nanoparticles in drug delivery*	*Nanoparticles for treatment of arsenic*	*Protein nanostructures*	*Polymer nanofiber field-effect transistors*
S-5	SLO-1	*Rechargeable batteries*	*Nanoparticles in targeted drug delivery*	*Mechanism of treatment methods of arsenic-contaminated water*	*Engineered nanoparticles in food*	*Multifunctional polymer nanocomposites*
	SLO-2	*Nanostructured electrodes*	*Metal oxide nanocarriers for drug delivery*	*Treatment of arsenic using nanoparticles other than TiO_2*	*Silica (SiO_2) and silicates nanoparticles in food*	*Electrospun carbon nanofiber: electrode material*
S-6	SLO-1	*Basic concepts of fuel cells*	*Silica-based nano drug delivery*	*CNTs in water treatment technology*	*Nanomaterials in active packaging for food preservation*	*Nano finishing in textiles: UV resistant, antibacterial*
	SLO-2	*Different types of fuel cells*	*Polymer based nanomaterials for drug delivery*	*Functionalized graphene for removal of contaminations and water treatment*	*Barrier nanomaterials for food packaging*	*Nano finishing in textiles: hydrophilic, self-cleaning*
S-7	SLO-1	*Photovoltaic cells characterization*	*Cancer diagnostics: nanotechnology*	*Gas-sensor: Techniques used for gas-*	*Nano-enabled indicators of food quality*	*Protective textile against electromagnetic*

				sensor	*and safety*	*radiation*
	SLO-2	*Nanomaterials and different types of photovoltaic cells*	*Cancer therapy: nanotechnology*	*Conduction mechanism in semiconducting sensing films*	*Challenges of using nanotechnology in agriculture and food sectors*	*Nanotechnology: Self-Cleaning textile*
S-8	SLO-1	*Electric double layer capacitors*	*Nano-sensor in cancer*	*Metal-oxide based gas-sensor devices*	*Nanomaterials in active packaging for food preservation*	*Safety evaluation of nanomaterials in cosmetic products*
	SLO-2	*Capacitance versus pore size*	*Nanoparticle probes and molecular imaging in Cancer*	*Classification of semiconductor sensors*	*Principles of involved nano-enabled sensing*	*Nanomaterial in cosmetic: determination of physicochemical properties*
S-9	SLO-1	*Characterization of nanoparticle coatings*	*Nanomedicine-based use of siRNA in cancer*	*Challenges and opportunities in solid state sensors*	*Nanocomposite with antimicrobial properties*	*Cosmetic formulation: TiO_2 and ZnO Nanoparticles*
	SLO-2	*Nanoparticle coatings:Electrical and electronic applications and nanoparticle coatings for electrical products*	*Magnetic Nanoparticles and cancer*	*Small dimensional toxic gas sensor for air-quality monitoring*	*Nanotechnology for intelligent packaging as food freshness and safety monitoring solution*	*Nanotechnology in shampoos, hair-conditioners: Hair follicle targeting*

Learning Resources	1. *Kenneth E.G., Craig R.H., Cato T.L., Lakshmi S.N., Biomedical Nanostructures, John Wiley & Sons Inc., 2008* 2. *P. J. Brown, K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead Publishing Limited, Cambridge, 2007* 3. *C. M. Hussain, A. K. Mishra, Nanotechnology in Environmental Science, Volume 2,John Wiley & Sons, 2018*	4. *M. A. Axelos, M. H. Van de Voorde, Nanotechnology in Agriculture and Food Science, John Wiley & Sons, 2017* 5. *M. H. Fulekar, Nanotechnology: Importance and Applications, IK International Publishing House Pvt. LTD, 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	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*30 %*	-	*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
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2. Dr. Krishna SurendraMuvvala, Saint Gobain Research India, India, Krishna.muvvala@saintgobain.com	*2. Dr. M. S. Ramachandra Rao, IIT Madras, msrrao@iitm.ac.in*	*2. Dr. Senthilkumar E, SRMIST*