ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 17
(Syllabi for Mechanical Engineering Programme Courses)
(Revised on July 2024)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MEC201T	Course Name	ENGINEERING THERMODYNAMICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*utilize the fundamental concepts of thermodynamic systems and energy transfer*
CLR-2:	*utilize thermodynamic laws and their applications*
CLR-3:	*utilize the evaluation of properties of pure substances and vapor power cycles*
CLR-4:	*utilize the fundamental concepts of Psychometric processes*
CLR-5:	*utilize the evaluation of properties of gas and gas mixtures*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concept of thermodynamic properties to quantify energy transfer*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply thermodynamic laws to various thermodynamic systems, comprehend Entropy, Availability concepts*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*determine the properties of pure substances and illustrate vapor power cycles*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*apply the fundamentals of Psychometric processes and do basic calculations*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*determine the properties of gas and gas mixtures*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Fundamentals and First Law of Thermodynamics	***9 Hour***
Thermodynamic system, Properties, Quasi-static process, Zeroth law of Thermodynamics, Pdv work for various quasi-static processes, First law of thermodynamics for a closed system, Process and cycle, First law applied to flow processes, Application of SFEE to various steady flow devices.	
Unit-2 - Second Law and its Applications	***9 Hour***
Cyclic heat engine, Carnot cycle, Reversed Carnot cycle, Carnot's theorem, Statements of second law and their equivalence - Reversible and irreversible process, Causes of irreversibility, Clausius theorem, Concept of entropy, Entropy generation in Closed systems, Concept of Availability	
Unit-3 - Steam Generation and Rankine Cycle	***9 Hour***
Pure substances, Phase change phenomenon of a pure substance, Property diagrams for phase change process, Use of Steam tables, Mollier chart, Rankine cycle, Rankine cycle efficiency, Reheat Rankine cycle and its efficiency, Concept of regeneration in Rankine cycle	
Unit-4 - Psychrometry	***9 Hour***
Properties of atmospheric air and Psychrometric chart, Psychrometric processes. Psychrometric processes, Winter air conditioning system, Year-round air conditioning systems, Heat load and simple calculations	
Unit-5 - Properties of Gases and Mixtures	***9 Hour***
Properties of ideal and real gases, Vander Waal's equation of state, compressibility chart, Properties of mixture of gases, Dalton's law of partial pressures, Amagat's law of additive volumes, simple problems, Maxwell's relations, T-ds relations, Clausius - Clapeyron Equation, Joule-Thomson experiment	

Learning Resources	1. *Mahesh M. Rathore, Thermal Engineering, Tata McGraw Hill Education, 2012* 2. *Yunus. ACengel., Michael A Boles, Thermodynamics – An Engineering Approach, 8th Tata McGrawHil Education, 2015 Edition* 3. *Nag. P.K, Engineering Thermodynamics, 5th ed., Tata McGraw Hill Education, 2013* 4. *R. K. Rajput, Thermal Engineering, 10th ed., Laxmi Publications (P) Ltd, New Delhi, 2017*	5. *Michael J Moran, and Howard N Shapiro, Fundamentals of Engineering Thermodynamics, 8th ed., John Wiley & Sons, New York, 2015* 6. *Claus Borgnakke, Richard E. Sonntag, Fundamentals of Thermodynamics, 7th ed., Wiley, 2009* 7. *Ramalingam. K. K, Steam tables, Sci.Tech Publishers, 2009*

Learning Assessment

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *PC M Velan Indian Navy*	1. *Dr G.Kumarasen, CEG, anna University*	1. *Dr G.Kasiraman, SRM IST*
2. *Mr . R.Karthick GM Operations Flexiflo India Pvt Limited Alwarpet Chennai,karthik@flexiflo.ae*	2. *Dr.Rajasekaran,University college of engineering,Villupuram*	2. *Dr K Suresh Kumar, SRM IST*

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

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

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

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

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

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

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

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

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

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

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

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

Unit-1 - Phase Diagram and Heat Treatment	9 Hour
Crystal structure, Imperfection in solids, Solid solutions – Types, factors governing solubility rules. Phase diagram – cooling curve, phase rule, types and interpretation. Iron- carbide (Fe-Fe3C) phase diagram, Microstructural aspects and invariant reactions in Fe-Fe3C diagram. Effect of alloying elements on Fe-Fe3C diagram. TTT and CCT diagrams. Various heat treatment and surface hardening process	
Unit-2 - Elastic and Plastic Behaviour of Materials	**9 Hour**
Stress Strain relation in elastic and plastic region, Mechanism of plastic deformation – slip and twinning, Slip systems, critically resolved shear stress, Shear strength of perfect and real crystals. Dislocation – climb, interaction, multiplication and pile ups. Strengthening mechanisms – Solid solution, Grain boundary, Dispersion, Precipitation, Fiber, Martensite strengthening, Strain aging and Strain hardening.	
Unit-3 - Characterization of Materials	**9 Hour**
Types of fracture in metals, Griffith's theory of brittle fracture, Stress intensity factor, Fracture toughness, Theory of Ductile to brittle transition. Creep – Creep curve, mechanism of creep deformation. Fatigue - S-N curve, low and high cycle fatigue, stages of fatigue. Sources of failure, Procedure of failure analysis. Hardness: Rockwell, Brinell, Vickers hardness, Nano-Indentation Technique. Introduction to characterization of materials - XRD, SEM and TEM.	
Unit-4 - Properties of Advanced Materials	**9 Hour**
Properties of plain carbon steel, Tool steel, Stainless steel, Cast iron. Need of microalloying, HSLA steel - Dual phase steel, TRIP steel. Aluminium alloys – classifications, properties, applications, Titanium alloys. Polymers – Types, Properties and applications of PE, PP, PVC. Ceramics – Types, Properties and applications of Al2O3, ZrO2, SiC. Composites – classification, Reinforcement and matrix material, Rule of Mixture. Properties and applications of MMC, CMC and PMC. Functionally graded materials.	

Unit-5 - Futuristic Materials and Computational Materials Design	***9 Hour***
Smart materials – Types, Shape memory alloys. Nanomaterials: Carbon nanotubes, Graphene – properties and applications. Metallic foams, Metallic glasses, Super alloys, High entropy alloys, biomaterials, Multi-scale materials modelling. Integrated Computational Materials Engineering with application to Industry 4.0. Materials Informatics, Machine learning for design of materials, Property Optimization	

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

Learning Assessment

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

Course Designers

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

Course Code	21MEC204T	Course Name	MANUFACTURING PROCESSES AND METROLOGY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*apply the concept of casting and mechanical metal working technology in manufacturing*
CLR-2:	*utilize the metal cutting principles and machine tool technology in manufacturing*
CLR-3:	*identify the various metal joining and additive manufacturing processes to make a component*
CLR-4:	*be familiar with basics of metrology and measurement of thread, gear and surface finish*
CLR-5:	*known the working of coordinate measuring machines and various optical methods for measurement*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*utilize metal casting and forming processes to create a product*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*acquaint the theory behind metal cutting and recognize various milling, gear manufacturing and surface finishing processes*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply various metal joining and additive manufacturing processes in industries to develop the products*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	2	-
CO-4:	*acquire the knowledge about the fundamentals of metrology, gear, thread and surface roughness measurement*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*implement the fundamentals of CMMs and apply the knowledge about the optical metrology in measurements*	-	-	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Metal Casting and Forming Technology ***9 Hour***

Introduction to casting, Patterns: Types and Materials-Types of Allowances and Moulding sand-Gates and Risering system-Numerical on Riser design- Special Casting Process - Die casting, Centrifugal Casting-Introduction to hot and cold working-Types of forging, Types of extrusion-Types of roll mills- Wire drawing-Sheet metal operation-Blanking, punching, stretch forming, bending, cup drawing, Embossing and coining-Numerical on bending and blanking

Unit-2 - Metal Cutting and Machine Tools ***9 Hour***

Orthogonal and oblique cutting - Classification of cutting tools: single, multipoint - Tool signature for single point cutting tool - Mechanics of orthogonal cutting – Numerical on Merchant Circle – Tool wear and tool life: Simple problems - Cutting Fluids- Gear Manufacturing and Generation Processes - Types of milling (up and down milling)-Computer numeric control (CNC) machine: Types and components - Types of grinding: Surface, Cylindrical and Center less Grinding

Unit-3 - Welding and Additive Manufacturing ***9 Hour***

Classifications of Welding Processes -Types of Welding Processes: Gas Metal Arc Welding, Cold metal transfer (CMT) welding, Spin Arc welding process, Laser welding, Friction welding process-Simple problems in welding-Basic Solidification Concepts and Grain structures in weld-Inspection and Testing Methods. Need and Development- Principle, working and applications of Additive Manufacturing process: Fused deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Selective Laser Sintering (SLS) and Laser Engineered Net Shaping (LENS).

Unit-4 - Introduction to Metrology and Measurement of Various Elements ***9 Hour***

Introduction to metrology, Need for inspection- Sources and types of errors- Precision and accuracy-Classification of measuring instruments- Standards of measurements, Calibration Comparators: Types and need, Mechanical (Sigma) and Electrical- Measurements of various elements of threads: Major, minor diameters and pitch-Measurement of effective diameter: two wire methods, best size wire and tutorials - Measurements of tooth thickness of gear by gear tooth vernier and tutorials- Circular pitch and composite error measurement-Surface roughness parameters- surface finish measuring instruments- Methods of evaluation of surface finish and simple problems in roughness evaluation

Unit-5 - Co-Ordinate Measuring Machine and Optical Metrology	***9 Hour***
Introduction to coordinate metrology- Types and construction of CMM- Components of CMM: Bearings, Drive systems, Transducers, Probes- measuring accuracy, causes of errors and calibration of CMM - Application of laser scanning CMM in reverse engineering- Principle of light wave interference- Types of interferometers: Michelson, NPL flatness and Laser interferometer-Measurement of straightness, flatness using Autocollimator- Machine vision: Image processing technique	

Learning Resources	1. *Serope Kalpakjian, Steven R Schmid Manufacturing Engineering and Technology, 7th ed., Pearson,2018* 2. *Mikell P. Groover, Fundamentals of Modern Manufacturing Materials, Processes, and Systems, 4th ed., John Wiley & Sons, 2014* 3. *A.C. Davies, The science and practice of welding, Vol. 1 and 2, 10th ed., Cambridge University Press, 2012* 4. *John C. Lippold, Welding Metallurgy and Weldability, John Wiley & Sons, 2015* 5. *Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2015.* 6. *Jain, R. K., "Engineering Metrology", Khanna Publishers, New Delhi, 2012*	7. *Kevin Harding, "Handbook of Optical Dimensional Metrology", CRC Press, A Taylor & Francis group, 2013.* 8. *Robert J. Hocken, Paulo H. Pereira, "Coordinate Measuring Machines and Systems", CRC Press, Taylor & Francis Group, 2016.* 9. *Galyer, J. F. W., and Shotbolt, C. R., Metrology for Engineering, Cassell London, 5th Edition* 10. *Toru Yoshizawa, "Handbook of Optical Metrology: Principles and Applications", CRC Press, 2014.* 11. *Heinrich Schwenke, Ulrich Neuschaefer-Rube, Tilo Pfeifer, Horst Kunzmann ,"Optical Methods for Dimensional Metrology in Production Engineering", CIRP Annals - Manufacturing Technology, 51(2) (2012) 685–699* 12. *Duraivelu K, Karthikeyan S. 'Engineering Metrology and Measurement'. University Press. First Edition (2018)*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. B. Arivalagan, Scientific officer, IGCAR, Kalpakkam*	1. *Dr. P.Sathiya, Professor, NIT-Trichy*	1. *Dr A.Vijaya, SRMIST*
2. *Mr. Bharath Kumar, Assistant manager, Rane-NSK, bharathkumar@nsk.com*	2. *Dr. Raju Abraham, Scientist-F, National Institute of Ocean Technology, Velachery-Tambaram Road, Pallikaranai, Chennai 601302, abraham@niot.res.in*	2. *Dr. S.Muralidharan, SRMIST*

Course Code	21MEC201L	Course Name	MANUFACTURING PROCESSES AND METROLOGY LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*be familiar of Machining operations in Centre lathe and CNC turning centers*
CLR-2:	*practice basic Gear making processes in Convention Milling Machines and Machining operations in CNC Milling Centers*
CLR-3:	*practice Cutting tool edge grinding, Surface finishing process and demonstration on MIG Welding*
CLR-4:	*be familiar on measuring profiles using profile projector and Machine vision system*
CLR-5:	*be familiar on geometric, form and surface roughness measurement using CMM and Calibration of Instruments*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*practice profile turning in Centre lathe and CNC lathe to create new components according to specified dimensions*	-	-	*1*	*3*	*1*	-	-	-	-	-	-	-	-	-	-
CO-2:	*practice Contour Milling, Gear Machining using CNC Milling and Special Machines*	-	-	*2*	*3*	*2*	-	-	-	-	-	-	-	-	-	-
CO-3:	*practice Surface and Cylindrical grinding, cutting tool edge grinding and acquire knowledge in MIG Welding*	-	-	*1*	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*practice profile measurements profile projector and Machine vision*	-	-	*1*	*3*	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*practice geometric, form and surface Measurements Using Coordinate Measuring Machine and Calibration of Instruments*	-	-	*2*	*3*	*1*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Profile Turning Using Center and CNC Lathe	***6 Hour***
Lathe- Step turning and chamfering- taper turning by compound rest/offset - drilling, external thread cutting and internal thread cutting. CNC lathe -plain and step turning- peck drilling, boring and external thread cutting - profile turning using canned cycles	
Unit-2 - CNC Contour Milling and Gear Manufacturing	***6 Hour***
Milling machine -Spur gear cutting Hobbing machine- Helical gear cutting CNC Milling center- Straight and contour milling -Circular and square pocketing - operations using Mirror cycle and canned cycles. Additive Manufacturing	
Unit-3 - Surface, Cylindrical Grinding and Friction Welding Process	***6 Hour***
Tool and cutter grinding- Surface grinding in grinding machine - Cylindrical grinding- cutting tool edge grinding -Friction Welding	
Unit-4 - Profile Measurements Using Profile Projector and Machine Vision	***6 Hour***
Basic Measuring Instruments, Angular Measurements using sine bar- sine center apparatus and tool makers microscope, Optical Instruments- Profile Projector, Machine Vision	
Unit-5 - Geometric, Form and Surface Measurements Using CMM and Quality Control	***6 Hour***
Geometric Measurements - calibration of measuring Instruments, Form Measurements using mechanical & electrical Probe; Surface roughness measurements using surface roughness tester, 3D measurements using coordinate measuring machine. Process control charts.	

Learning Resources	1. *A Textbook of Manufacturing Technology (Manufacturing Processes, R K Rajput, Laxmi Publications (P) Ltd, 2018* 2. *S. K. H. Choudhury, A. K. H. Choudhury and N. Roy, Elements of Workshop Technology, Volume I: Manufacturing Processes, Media Promotors, 2008* 3. *CNC Machining Handbook: Building, Programming, and Implementation, Allan Overby, McGraw-Hill December-2010*	4. *Manufacturing Process Laboratory Manual,SRMIST, 2022* 5. *Laboratory observation manual* 6. *Machine manuals supplied by company/supplier.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Ramesh Ramanathan, COO -CONMET- North America*	1. *Dr. N.E.Arun Kumar PhD, Associate Professor Department of Mechanical Engineering St. Joseph's College of Engineering, OMR,Chennai*	1. *Mr. S. Shakthivel, SRMIST*
2. *S.A.Krishnan, Scientist, IGCAR, Kalpakkam*	2. *Mr.S.Samsudeen, National Skill Training Institute, CTI Campus, ssamsadt@gmail.com*	2. *.Mr.V.G.Umasekar, SRMIST*

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

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

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

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

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

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

Learning Assessment

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

Course Designers

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

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

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

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

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

Unit-1 - Fluid Properties and Fluid Statics — ***9 Hour***

Types of fluids, Properties of fluid, Dynamic and Kinematic viscosity - Newton's law of viscosity- Surface tension and capillarity- -Bulk modulus of elasticity and compressibility, Fluid statics: Pascal's law, Hydrostatic law, Buoyancy and Meta centre, Pressure, Manometers - Piezometer- Applications and limitation - U-Tube, Single column, Differential U-tube, Inverted differential U-tube manometers.

Unit-2 - Fluid Kinematics and Dynamics — ***9 Hour***

Types of fluid flow, Lagrangian and Eulerian approach, Velocity and acceleration of fluid particles- Continuity equation- Euler equation of motion-Bernoulli's equation- Applications - Venturimeter- Orificemeter -Pitot tube-Nozzle flow meter- Types of flow lines, Stream line-Streak line and Path line-Impulse Momentum equation.

Unit-3 - Dimensional Analysis and Flow Through Pipes — ***9 Hour***

Dimensions, Dimensional homogeneity-Buckingham's pi theorem-Model analysis-advantages and applications-similitude, Dimensionless numbers-Model laws- Reynold's, Froude, Weber, Mach, and Euler model laws, Concept of fully developed pipe flows - Darcy equation –Major and minor losses-Pipes connected in series and parallel-Equivalent pipe.

Unit-4 –Boundary Layer and Flow Around Submerged Bodies — ***9 Hour***

Flow over flat plate - Laminar and turbulent boundary layers - Von Karman momentum integral equation - Boundary layer thickness – Displacement, momentum and energy thickness - Forces exerted by a flowing fluid on a stationary bluff and streamlined bodies -Separation of flow over bodies - Development of lift and drag forces.

Unit-5 - Hydraulic Machines — ***9 Hour***

Pumps and turbines - Classification - Centrifugal and reciprocating pumps - Working principle - Design parameters -Velocity triangle - Performance curves – Pelton turbine, Francis turbine and Kaplan turbine, - Working principle - Design parameters - Velocity triangle – Performance curves - Cavitation in pumps and turbines.

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

Learning Assessment

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

Course Designers

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

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

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

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

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

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

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

Learning Assessment

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

Course Designers

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

Course Code	21MEC203L	Course Name	MACHINE DYNAMICS LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*demonstrate the basic concepts of kinematics involved in various machine elements*
CLR-2:	*demonstrate the basic concepts of dynamics involved in various machine elements*
CLR-3:	*demonstrate the free vibration of linear and torsional spring, mass and damper systems*
CLR-4:	*demonstrate the forced vibration of beams and shafts subjected to rotating unbalancing forces*
CLR-5:	*demonstrate the working principles of vibration measuring instruments*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*demonstrate the concepts of kinematics of machine elements*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*demonstrate the concepts of dynamics of machine elements*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze the free vibration of Single degree of freedom systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze the forced vibration of Single degree of freedom systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*analyze the experimental vibration response using digital signal analysis techniques*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Kinematic Analysis of Machine Elements	***6 Hour***
Cam and Follower - Epicyclic gear train -	
Unit-2 - Dynamic Analysis of Machine Elements	***6 Hour***
Gyroscope -Dynamic balancing of rotating and reciprocating masses- Demonstration of Governors	
Unit-3 - Free Vibration Analysis	***6 Hour***
Free vibration of helical springs - Torsional vibration of single rotor system - Free vibration of equivalent spring, mass and damper system	
Unit-4 - Forced Vibration Analysis	***6 Hour***
Transverse vibration of beam - whirling of shaft- Transmissibility ratio in vibrating systems	
Unit-5 - Experimental Vibration Analysis	***6 Hour***
Measurement of vibration response using strain gauge, accelerometer and Impact hammer- single plane and two plane balancing using Balancing machines	

Learning Resources	1. *Rao SS, 'Mechanical Vibrations, 5th Edition, Prentice Hall* 2. *Thomas Bevan, Theory of Machines, 3rd Edition – Pearsons Education Limited – 2005 – 3rd Edition*	3. *Robert L. Norton, Kinematics and Dynamics of Machinery, 2nd Edition, McGraw Hill, 2013.* 4. *Sujatha C., Vibration and Acoustics - Measurement and Signal Analysis, Tata McGraw Hill Education Pvt. Ltd., 2010*

Learning Assessment

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

Course Designers

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

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

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

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

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

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

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

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

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

Course Code	21MEC205L	Course Name	MECHANICAL MODELING AND ASSEMBLY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

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:	*implement the basics of standards and conventions, limits, fits and tolerances pertaining to mechanical modeling and assembly of components*
CLR-2:	*develop the assembly and detailed drawing of mechanical joints and couplings*
CLR-3:	*develop the assembly and detailed drawing of Bearings and Engine components*
CLR-4:	*prepare the assembly drawing and detailed of Work holding and Lifting device*
CLR-5:	*create the assembly and detailed drawing of Machine components and Fixture*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply various standards and conventional representation of machine components and choose appropriate fits*	*3*	-	-	-	-	-	-	-	-	*2*	-	-	-	-	-
CO-2:	*develop the assembly drawing of mechanical joints and couplings*	*2*	-	-	-	*3*	-	-	-	-	*3*	-	-	-	-	-
CO-3:	*develop the assembly drawing of Bearings and Engine components*	*2*	-	-	-	*3*	-	-	-	-	*3*	-	-	-	-	-
CO-4:	*develop the assembly drawing of Work holding and Lifting device*	*2*	-	-	-	*3*	-	-	-	-	*3*	-	-	-	-	-
CO-5:	*develop the assembly drawing of Machine components and Fixture*	*2*	-	-	-	*3*	-	-	-	-	*3*	-	-	-	-	-

Unit-1 - Standards, Conventions, Symbols, Fits and Tolerances	***12 Hour***
IS/ISO codes, Conventional representation of machine elements-springs-gear drives, Abbreviations, welding symbols, riveted joints, keys, fasteners and Bill of materials, Limits, Tolerances, Computing fundamental deviation Fits-classification-system of fits-hole basis system-shaft basis system, geometric characteristic symbols, geometric tolerances.	
Unit-2 - Joints and Couplings	***12Hour***
Modeling, Assembly and Detailed drawing of Joints and Coupling.	
Unit-3 - Bearings and Engine Components	***12 Hour***
Modeling, Assembly and Detailed drawing of Bearings and engine components.	
Unit-4 - Work Holding and Lifting Device	***12 Hour***
Modeling, Assembly and Detailed drawing of work holding, lifting, hoisting, cranes, jacks and chucks.	
Unit-5 - Machine Components and Fixture	***12 Hour***
Modeling, Assembly and Detailed drawing of machine components and fixtures.	

Learning Resources		
	1. *N. D. Bhatt, Machine Drawing, Charotar Publishing House Pvt Ltd, 2016.*	4. *SP 46: 1988 Engineering Drawing Practice for School & Colleges. Bureau of Indian Standards*
	2. *N. Sidheswar, P. Kanniah and V.V.S. Sastry, Machine Drawing, Tata McGraw Hill, 2010.*	5. *K. R. Gopalakrishna, Machine Drawing, 20th Ed., Subhas Stores, Bangalore, 2007.*
	3. *K. L. Narayana, P. Kannaiah, K. Venkata Reddy – 'Machine Drawing' – New Age International publishers – 2019 – 6 Edition*	6. *Design Data: Data Book of Engineers by PSG College of Technology - Kalaikathir Achchagam, 2020*

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

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

Course Code	21MEC301T	Course Name	THERMAL SYSTEMS ENGINEERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	1	0	4

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the sequence of operation of air standard cycles*
CLR-2:	*identify the fundamentals of Fuels and performance of IC Engines*
CLR-3:	*familiar with thermal performance of boiler and heat exchanger*
CLR-4:	*identify the working of different types of compressors*
CLR-5:	*understand the cooling performance of refrigeration and its applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the basic operations required for cyclic energy release and method to calculate the efficiency*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*examine the fuel properties and performance of IC engines*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*investigate the thermal performance of boiler and heat exchanger*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*investigate the thermal performance of compressor*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*investigate the cooling performance of refrigeration systems*	*3*	-	-	-	-	-	*1*	-	-	-	-	-	-	-	-

Unit-1 - Air Standard Cycles	***12 Hour***
Air standard cycles – Otto, Diesel, Dual and Brayton-- Air standard efficiency - Mean effective pressure - Comparison between cycles - Concept of reheat and regeneration for Brayton cycle.	
Unit-2 - Fuel Combustion and IC Engines	***12 Hour***
Fuels – types and properties -- air fuel ratio - volumetric and gravimetric analysis - Analysis of exhaust and flue gas – Calorimetry. IC engines - classification, Working of two stroke and four stroke engines – Measurement of engine operating parameters, Engine performance and Heat balance sheet.	
Unit-3 - Boilers and Heat Exchangers	***12 Hour***
Boiler –classification- Mountings and accessories – High pressure boilers – requirements – Working of Lamont , Loeffler, Benson and Velox boiler, fluidized bed boiler, Waste heat recovery boiler, sub critical and super critical boilers – Boiler performance- Equivalent evaporation- Factor of evaporation – Boiler efficiency, Function, types and working of condensers, Economiser, Air preheater, super heater	
Unit-4 - Air Compressor	***12 Hour***
Air compressor - classification, working of reciprocating air compressor with and without clearance - Equation for work on single stage compressor - Volumetric efficiency and Free air delivered - Multistage compression with intercooler, Positive rotary compressors - working- Comparison between reciprocating and rotary compressor.	
Unit-5 - Refrigeration and its Applications	***12 Hour***
Vapor compression refrigeration system and its working principle – Refrigerants – Eco-friendly refrigerants, Analysis of vapor compression refrigeration cycle- theoretical and actual cycles - Sub-cooling and superheating - Vapor absorption refrigeration systems –Li-Br, NH3-water, Adsorption cooling system ,Steam jet refrigeration system, HVAC system in automobiles, Thermal processing of dairy and ice plants, thermal comfort in buildings, thermoelectric refrigeration, Summer, winter and year round air-conditioning system.	

Learning Resources	1. *Mahesh Rathore, Thermal Engineering, Tata McGraw Hill, 2012* 2. *Eastop T. D., Mcconkey. A, Applied Thermodynamics for Engineering Technologists, 5th ed., Pearson Edition, 2009* 3. *Kenneth A Kroos, Merle C. Potter, Thermodynamics for Engineers, Cengage learning, 2016*	4. *Rajput.R. K, Thermal Engineering, 11th ed., Laxmi Publications, 2023* 5. *Yunus A Cengel, Michael A Boles, Thermodynamics: An Engineering Approach,9th ed., Tata McGraw Hill, 2018*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *PC M Velan Indian Navy*	1. *Dr. Arun Vijay, Anna university Tirunelveli*	1. *Mr N. Vijay Krishna, SRMIST*
2. *Mr. R. Karthick GM Operations*	2. *Dr. Rajasekaran, University college of engineering, Villupuram*	2. *Dr. R. Senthil Kumar, SRMIST*
		3. *Dr. V. Praveena. SRMIST*

Course Code	21MEC301P	Course Name	DESIGN OF MECHANICAL SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the fundamentals of mechanical design*
CLR-2:	*be familiar with the concepts to design joints and couplings*
CLR-3:	*know the concepts to design IC engine components*
CLR-4:	*be familiar with the concepts to design gears*
CLR-5:	*know the concepts to design gear box*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply failure theories in designing the components*	*3*	-	*3*	-	-	-		-	*2*	-	-	-	-	-	-
CO-2:	*design joints and couplings*	*3*	-	*3*	-	-	-		-	*2*	-	-	-	-	-	-
CO-3:	*design IC engine components*	*3*	-	*3*	-	-	-		-	*2*	-	-	-	-	-	-
CO-4:	*design gears with strength and wear*	*3*	-	*3*	-	-	-		-	*2*	-	-	-	-	-	-
CO-5:	*select the number of teeth on each gear and prepare layout of gear box*	*3*	-	*3*	-	-	-		-	*2*	-	-	-	-	-	-

Unit-1 - Fundamentals of Mechanical Design	***9 Hour***
Introduction to the design process - factors influencing machine design, selection of materials based on mechanical properties -Theories of failure - Design for variable loads: endurance limit, Goodman and Soderberg criteria.	
Unit-2 - Design of Joints, Couplings and Shafts	***9 Hour***
Design of joints - Cotter, Knuckle and Bolted joints, Design of couplings - Rigid and flexible couplings-design of shafts	
Unit-3 - Design of IC Engine Components	***9 Hour***
Design of Cylinder, Piston with pin and rings, Connecting Rod and Crank Shaft.	
Unit-4 - Design of Gears	***9 Hour***
Design of spur, helical, bevel and worm gears from strength and wear considerations.	
Unit-5 - Design of Gear Box	***9 Hour***
Design of multi speed gear box - Requirements of gear box, determination of variable speed range, graphical representation of speeds, structure diagram, ray diagram, selection of optimum ray diagram, estimation of numbers of teeth on gears, layout of gear box.	

Learning Resources	1. *Joseph Shigley, Richard G. Budynas and J. Keith Nisbett "Mechanical Engineering Design", McGraw-Hill International Editions 10th Edition, 2015.* 2. *Robert. C. Juvinall, Kurt. M. Marshek, "Fundamentals of Machine Component Design", John Wiley &sons, 6th Edition, 2017.* 3. *Paul H Black and O. E. Adams, P., "Machine Design", 3rd edition, Mc Graw Hill Book Company, Inc., New York, USA, 2007.*	4. *Bhandari V B, "Design of Machine Elements", 4th Edition, Tata McGraw-Hill Book Co, 2016* 5. *Mehtha. N. K, "Machine Tool Design and Numerical Control", Tata Mc- Graw Hill, Third Edition, 2012* 6. *Design Data: Data Book of Engineers, PSG College Technology, Kalaikathir Achchagam, Coimbatore, 2015* 7. *Gitin M Maitra, "Handbook of Gear Design", Tata Mcgraw-Hill, 2010*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (20%)		*Project Based Learning CLA-2 (60%)*		*Report and Viva Voce (20%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	*25%*	-	-	*25%*	-	*25%*	-	-
Level 3	*Apply*	*30%*	-	-	*30%*	-	*30%*	-	-
Level 4	*Analyze*	*30%*	-	-	*30%*	-	*30%*	-	-
Level 5	*Evaluate*	-	-	-		-	-	-	-
Level 6	*Create*	-	-	-		-	-	-	-
	Total	*100 %*		*100 %*		*100%*		-	

Course Designers

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

Course Code	21MEC302T	Course Name	SENSORS AND CONTROL SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*be familiar with the sensors and transducers, which are commonly used in automation systems*
CLR-2:	*apply the knowledge advanced sensors technology commonly used in automation systems*
CLR-3:	*be familiar with the working of various drives, valves and actuators for Industrial Automation*
CLR-4:	*apply the knowledge about the controller used in industrial automation signal conditioning and data acquisition techniques*
CLR-5:	*be familiar with the knowledge of sensor in industrial automation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquaint with the sensors and transducers, which are commonly used in automation systems*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*acquaint with the advanced sensors technology commonly used in automation systems*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*explain the working of various drives, valves and actuators for Industrial Automation*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*provide the knowledge about the controller, PLC programming and control, signal conditioning and data acquisition techniques*	-	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*apply the knowledge of sensor in industrial automation*	-	-	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Sensors and Transducers ***9 Hour***

Introduction to sensors and transducers, classification and Static and dynamic characteristics, errors- Principle and working of Resistive, capacitive, inductive transducer- Resonant transducer, Photo electric sensor, Fibre optic transducers, piezoelectric sensor, Ultrasonic sensors- Photo detector-Vision systems

Unit-2 - Advanced Sensor Technology ***9 Hour***

Measurement of Motion, Force, Torque and flow Displacement and speed measurement for translational and rotation systems using potentiometers, LVDT and RVDT, Position Encoder Sensors -Force and Torque measurements using strain gauges and piezoelectric pickups. Flow measurements using Flow meter. Sensor for Identification Bar-Code Identification Systems -Electromagnetic Identification -Optical Character Recognition –Smart sensor/Intelligent sensor Sensors for Faults Diagnosis Sensors Detecting Faults in Dynamic Machine Parts using Surface Acoustic Waves-Sensors for Vibration Measurement of a Structure Microelectromechanical systems (MEMS)

Unit-3 – Drives Valves and Actuators for Industrial Automation ***9 Hour***

Definition, types and selection of Actuators; linear; rotary; Logical and Continuous Actuators, Pneumatic actuator- Electro-Pneumatic actuator; cylinder, rotary actuators, Mechanical actuating system: Hydraulic actuator - Control valves; Construction, Characteristics and Types, Selection criteria. Electrical actuating systems: Solid-state switches, Solenoids, Electric Motors- Principle of operation and its application: D.C motors - AC motors - Single phase & 3 Phase Induction Motor; Synchronous Motor; Stepper motors - Piezoelectric Actuator- Linear Electrical Actuators- Micro Actuators

Unit-4 - Controllers and Signal Processing ***9 Hour***

Programmable Logic Controllers – Architecture – Input / Output Processing – Logic Ladder Programming – Functional Block Programming using Timers and Counters – Applications. A/D converters, D/A converters Multiplexer and Proportional, Integral, Derivative and PID controller- Introduction to Micro controller- Open loop and closed loop control system. Basic signal conditioning – bridges, amplifiers, filters, monitoring and indicating systems and data acquisition systems.

Unit-5 – Application of Sensors and Case Studies in Automation	***9 Hour***
The Roles of Sensors in Industrial Automation- Components of Automation- applications of sensing systems in Automation: Assembly line automation- Testing, Inspection and Quality control, System health Monitoring- Significance of sensors for industry 4.0: Roles, capabilities, and applications	

Learning Resources		
	1. *Ernest O. Doebelin, Dhanesh N. Manik, Doebelin's Measurement Systems: 7th Edition (SIE), Tata McGraw- Hill, 2019.* 2. *Katsuhiko Ogata, Modern Control Engineering, 5th Edition, Prentice Hall of India Pvt. Ltd, 2010.* 3. *Patranabis D, Instrumentation and Control, PHI Learning Pvt. Ltd, 2011*	4. *Anthony Esposito, "Fluid Power with applications", Pearson Education Inc, 2015.* 5. *Soloman S. Sensors and control systems in manufacturing. McGraw-Hill Education; 2010.* 6. *Jacob Fraden, "Handbook of Modern Sensors Physics, Designs, and Applications", 5th Edition, Springer International Publishing, 2016.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Venkadesan Velu Founder & CEO @ LogFuze Inc.*	1. *Dr. A.S.S. Balan Assistant Professor, Department of Mechanical Engineering, NITK Surathkal, Mangalore, India*	1. *Dr. M. Prakash, SRMIST*
2. *Dr. Kulasekharan N Simulation Discipline Leader, Valeo India Pvt. Ltd.*	2. *Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	2. *. Dr. Ambigai, SRMIST*

Course Code	21MEC301L	Course Name	THERMAL POWER SYSTEMS LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the valve and port timing diagram, fuel properties*
CLR-2:	*understand the performance of IC engines*
CLR-3:	*understand the heat balance concept and emission testing*
CLR-4:	*get familiar with the working of boiler, steam turbine and air compressor*
CLR-5:	*understand the performance calculation of the blower and solar flat plate collectors*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*demonstrate the valve and port timing diagram, Analyze the properties of lubricants and fuels*	*3*	-	-	-	-	-	*3*	-	*3*	-	-	-	*1*	-	-
CO-2:	*test the performance of IC engines*	*3*	-	-	-	-	-	*3*	-	*3*	-	-	-	*1*	-	-
CO-3:	*detect the losses in heat balance test and emissions from the IC engine*	*3*	-	-	-	-	-	*3*	-	*3*	-	-	-	*3*	-	-
CO-4:	*analyze the performance of the boiler, steam turbine and air compressor*	*3*	-	-	*1*	-	-	*3*	-	*3*	-	-	-	*3*	-	-
CO-5:	*evaluate the performance of the blower and solar flat plate collectors*	*3*	-	-	-	-	-	*3*	-	*3*	-	-	-	*1*	-	-

Unit-1 - Basics of IC Engine and Fuel Properties	***6 Hour***
Components of Internal combustion engine, Valve timing and port timing diagram of IC Engines, Determination of viscosity, flash point, fire point, cloud and pour point	
Unit-2 - Performance Test on IC Engines	***6 Hour***
Performance test on single cylinder petrol engine with electrical dynamometer, diesel engine with Rope brake/ Eddy current/hydraulic dynamometer, Optimum cooling water flow rate in four stroke engine, Morse Test	
Unit-3 - Heat Balance Test on IC Engine	***6 Hour***
Heat balance test on four stroke diesel engine with and without calorimeter, Retardation test on low speed diesel engine, Determination of brake specific emission s, Emission standards.	
Unit-4 - Power Generation	***6 Hour***
Performance of steam power plant, solar flat plate collectors	
Unit-5 - Compressors and Blowers	***6 Hour***
Performance test on two stage reciprocating air compressor and blower	

Learning Resources	
	1. *Ganesan. V, Internal Combustion Engines, Tata McGraw-Hill, New Delhi, 2015.* 2. *Mathur.M. L, Sharma. R. P, A course in Internal Combustion Engines, DhanpatRai& Sons, 2010.* 3. *Laboratory Manual.*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.R.M.Raghunathan, Assistant Vice President, Tamil Nadu Petroproducts Limited, Manali, Chennai- 600068 mlrmr@hotmail.com	1. Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in	1. Dr.G.Balaji, SRMIST
2. Er.M.Sakthivel, Dy.Chief Engineer, NLC Limited, Neyveli – 607801, Tamil Nadu sakthivel.m@nlcindia.in	2. Dr.G.Arun Vijay, Anna University, Nagercoil, arunvijay.gs@gmail.com	2. Mr.G.Manikandaraja, SRMIST

Course Code	21MEC302L	Course Name	AUTOMATION AND CONTROL SYSTEMS LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*design pneumatic circuits for low-cost automation*
CLR-2:	*design hydraulic circuits for industrial automation*
CLR-3:	*develop electro pneumatic circuits, control of motors for various applications*
CLR-4:	*acquire sensors outputs using virtual instrumentation for various applications*
CLR-5:	*operate robot for pick and place robot and sorting and impart concepts of IOT for real time application*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*develop pneumatic circuits for low-cost automation*	-	-	*3*	-	-	-	-	-	*1*	-	-	-	-	-	-
CO-2:	*develop hydraulic circuits for industrial automation*	-	-	*3*	-	-	-	-	-	*1*	-	-	-	-	-	-
CO-3:	*construct electro pneumatic circuits, control of motors for various applications*	-	-	*2*	-	-	-	-	-	*2*	-	-	-	*1*	-	-
CO-4:	*acquire and analyse sensor outputs using virtual instrumentation for various applications*	-	-	*2-*	-	*1*	-	-	-	*2*	-	-	-	-	-	-
CO-5:	*manipulate robot for pick and place, sorting and impart concepts of IOT for real time applications*	-	-	*2*	-	*2-*	-	-	-		-	-		-	*2*	-

Unit-1 - Pneumatic Circuits	***6 Hour***
Double Acting Cylinder - Continuous, Speed Control, Sequencing, Cascading of Cylinders Circuit	
Unit-2 - Hydraulic Circuits	***6 Hour***
Double Acting cylinders - Logic Functions. Automatic material handling system integrating sensors	
Unit-3 - Electro Pneumatic Circuits and Control of Actuators	***6 Hour***
Electro Pneumatic - Synchronization, sequencing Circuit. AC Servo Motor - open and closed loop control system. PID Controller- manual gain tuning of DC motor	
Unit-4 - Virtual Instrumentation	***6 Hour***
Process Control - Temperature, Pressure, Force, Accelerometer.	
Unit-5 - Robot and Iot for Real Time Applications	***6 Hour***
Robot - Pick and Place operation Obstacle Avoidance, Vision based Palletizing operation. IoT kit - Temperature, vibration Measurement and analysis during machining.	

Learning Resources	
	1. *Laboratory Manual* 2. *Anthony Esposito, "Fluid Power with applications", Pearson* 3. *Education Inc, 2015.* 4. *FESTO manual, "Fundamentals of Pneumatics", Vol I, II and III. JojiParambath "Industrial Hydraulic Systems: Theory and Practice", Universal Publishers, USA, 2016*
	5. *Sanjay Gupta, Joseph John Virtual Instrumentation Using Lab VIEW Tata MaGraw-Hill (2005) D Patranabis, Sensors and Transducers,* 6. *S. Misra, C. Roy, and A. Mukherjee, 2020. Introduction to Industrial Internet of Things and Industry 4.0. CRC Press.*

Learning Assessment									
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*15%*	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	-	*25%*	-	*20%*	-	*25%*	-	-
Level 3	*Apply*	-	*30%*	-	*35%*	-	*30%*	-	-
Level 4	*Analyze*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100%*		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. N Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability, Mahindra Research Valley.*	1. *Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	1. *Dr. R.Ambigai, SRMIST*
2. *Dr.Kulasekharan N Simulation Discipline Leader, Valeo India Pvt. Ltd.*	2. *Dr.S.Saravanaperumal, Assistant Professor, Department of Mechanical Engineering, Thiagarajar College of Engg., Madurai.*	2. *Mr.V.Manoj Kumar, SRMIST*

Course Code	21MEC301J	Course Name	HEAT AND MASS TRANSFER	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*apply the basic laws to solve problems in steady and unsteady state conduction systems*
CLR-2:	*apply the numerical techniques to solve one dimensional heat conduction problems*
CLR-3:	*apply the convection principles in simple geometries and to design heat exchangers*
CLR-4:	*apply the laws of radiation in black and grey surfaces*
CLR-5:	*apply the laws of heat transfer for phase change and mass transfer*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*solve the steady and unsteady state heat conduction problems in simple and composite systems*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*solve the one-dimensional heat conduction problems using numerical methods*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*compute the heat transfer coefficient under free and forced convection in various geometries and simple design of heat exchangers*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*examine the surface and gas radiation for black and grey bodies*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*compute the heat and mass transfer coefficient for phase change process and mass transfer*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Conduction ***15 Hour***

Modes of heat transfer, General conduction equation- boundary and initial conditions, One Dimensional Steady State Heat Conduction — plane and Composite Systems, Conduction with Internal Heat Generation, Extended Surfaces, Unsteady Heat Conduction – Lumped system analysis – Semi Infinite and Infinite Solids –Use of Heisler's charts Experiment on Heat transfer through composite lagged pipe, Experiment on natural and forced convection heat transfer – from PIN-FIN Apparatus.

Unit-2 - Numerical Methods in Heat Transfer ***15 Hour***

Taylor series expansion, Finite difference equations (FDE) of 1st, and 2nd order derivatives, Truncation errors, order of accuracy, Application of FDM in Steady and unsteady one dimensional heat conduction equation Practice on one dimensional steady and unsteady state heat conduction in finned systems.

Unit-3 - Convection and Heat Exchangers ***15 Hour***

Free and Forced convection – Non dimensional numbers, Boundary layer concept, Free Convection – Flow over vertical plate, horizontal plate, cylinders and spheres, Forced convection- Internal flow, External flow Flow over flat plates, Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors. LMTD and NTU methods Experiment on natural convection heat transfer - vertical tube, Experiment on forced convection heat transfer - horizontal tube, Experiment on Parallel and Counter flow Heat Exchanger and shell and tube heat exchanger, Experiment on performance test on vapour compression refrigeration test rig and air conditioning test rig

Unit-4 - Radiation ***15 Hour***

Radiation laws, Black and Gray body Radiation, Shape Factor. Electrical Analogy. Radiation Shields, Gas radiation Experiment on radiation using emissivity apparatus and Stefan Boltzmann apparatus

Unit-5 - Phase Change Heat and Mass Transfer ***15 Hour***

Nusselt's theory of condensation- Regimes of Pool boiling and Flow boiling, correlations in boiling and condensation., Fick's law of diffusion, Steady state diffusion through plane membrane, Equimolar counter diffusion, Isothermal evaporation of water vapour into air, Convective mass transfer. Experiment on dropwise and filmwise condensation

Learning Resources	1. *Sachdeva, R.C., Fundamentals of Heat and Mass Transfer, 2nd Edition, New Age International (P) Ltd., New Delhi,2017.* 2. *Nag, P.K., Heat Transfer and Mass Transfer, Tata McGraw Hill, 3rd Edition, New Delhi, 2011.* 3. *Ozisik. M. N, "Heat Transfer", McGraw-Hill Book Co., 2003.* 4. *Holman. J. P "Heat and Mass Transfer" Tata McGraw-Hill, 2008.* 5. *Yunus A. Çengel, Afshin J. Ghajar "Heat and Mass Transfer", Tata McGraw Hill Education, 2017.*	6. *Theo dore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, "Fundamentals of Heat and Mass Transfer", John Wiley and Sons, 2016. DATA BOOKS* 7. *Ko thandaraman. C. P, Subramanyan, S, "Heat and Mass Transfer Data Book", New Age International, 7th edition, 2012.* 8. *K.K.Ramalingam "Steam Tables", SciTech Publications, 2015*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.PCM. Velan, Indian Navy*	1. *Dr.Shaligram Tiwari, Professor, IIT Madras*	1. *Dr. D. Premnath, SRMIST*
2. *Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	2. *Dr. G Kumaresan, Professor, Anna university, Chennai*	2. *Dr.P. Chandrasekaran, SRMIST*

Course Code	21MEC302J	Course Name	FINITE ELEMENT METHODS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*find the approximate solution of boundary value problems*
CLR-2:	*develop basic finite element concepts and solution procedure for one dimensional problem*
CLR-3:	*find the finite element solution for two dimensional problems*
CLR-4:	*formulate and Solve Eigen value problems in Mechanical Engineering*
CLR-5:	*formulate and solve problems in heat transfer and Fluid dynamics using finite element method*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*find the approximate solution of boundary value problems*	-	*3*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*develop basic finite element concepts and solution procedure for one dimensional problem*	-	*3*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-
CO-3:	*find the finite element solution for two dimensional problems*	-	*3*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*formulate and Solve Eigen value problems in Mechanical Engineering*	-	*3*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*formulate and solve problems in heat transfer and Fluid dynamics using finite element method*	-	*3*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Solution of Ordinary Differential Equations ***15 Hour***

Overview of Engineering systems: Continuous and discrete systems – Solution of governing equations by Variational principles and weighted residual techniques for one-dimensional differential equations. Finite element formulations by Rayleigh-Ritz and Galerkin's methods. Spring element-stiffness matrix, assembly procedure of global stiffness matrix, load vector- solution methods for linear algebraic equations. Gauss elimination method.

Practice:

Solution of differential equations by variational and weighted residual methods

Solution of differential equations by finite element method

Unit-2 - One Dimensional Structural Analysis ***15 Hour***

Development of bar element-Governing equation - Minimum potential energy concept-higher order bar elements- application to trusses- Beam elements- natural coordinates- formulation of element stiffness matrix and load vectors

Practice:

Solution of bar/truss/beam problems

Derivation of stiffness matrix and load vectors for higher order elements

Unit-3 - Finite Element Analysis of Two Dimensional Problems ***15 Hour***

Theory of two dimension elasticity-plane stress and strain conditions- derivation of shape function and element matrices of constant strain and linear strain triangle elements-Four node quadrilateral elements-isoparametric formulation-Lagrange and serendipity family elements-Higher order elements-Gauss quadrature for numerical integration-axi-symmetric problems

Practice: 1.Static analysis of plate with plane stress/strain conditions using triangular and quadrilateral elements

Unit-4 - Structural Dynamics	***15 Hour***
Hamilton's Principle- lumped and consistent mass matrices for bar, beam and triangular elements-formulation of Eigen value problems in solid mechanics-natural frequency and normal modes for axial vibration of bar and transverse vibrations of beams-forced vibration response-Numerical time integration (Finite Difference Method, Runge-Kutta method) *Practice:* *Determination of natural frequencies and mode shape of axial vibration of bar* *Determination of natural frequencies and mode shape of transverse vibration of beams*	
Unit-5 - Heat and Fluid Flow Problems	***15 Hour***
Basics of Heat transfer-Governing equations and boundary conditions-Derivation of conductivity, convection and capacitance matrices and thermal load vectors for one dimensional element- steady state and transient heat conduction in one dimension-One dimensional potential fluid flow problems- Introduction to finite element software packages *Practice:* *steady state heat transfer problem* *transient heat transfer problem* *Demo on Finite Element software with advanced modules such as solidification, machining, forming, additive manufacturing processes*	

Learning Resources	1. *Hutton, D.V., "Fundamentals of Finite Element Analysis", McGraw Hill, International Edition, 2004.* 2. *Belegundu, Ashok D.; Chandrupatla, Tirupathi R, "Introduction to Finite Elements in Engineering", Pearson 2012* 3. *J.N Reddy, An introduction to the Finite Element Method, 2005, Mcgraw Hill*	4. *S.S. Rao, The Finite Element method in Engineering, Elsevier Science &Technology Books, 6th edition, 2018.* 5. *K.J. Bathe, Finite Element Procedures, Prentice Hall, Pearson Education, Inc, 2nd edition, 2014* 6. *Cook R.D., Malkus, D.S., Plesha, M.E., Witt, R.J., "Concepts and Applications of Finite Element Analysis", 4th Edition, John Wiley & Sons, 2001*

Learning Assessment

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

Course Designers

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

Course Code	21MEC303T	Course Name	INDUSTRY 4.0	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*explore the need of industry 4.0, IOT architecture and its protocols*
CLR-2:	*interpret the big data usage and the cyber threads on Industry 4.0*
CLR-3:	*reason out the use of cloud computing and data analytics in Industry 4.0*
CLR-4:	*familiar the concepts of digital manufacturing*
CLR-5:	*learn the real time usage of IOT, cloud computing, data analytics in Industry 4.0*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*realize the need of industry 4.0 and interpret the architecture of IOT and its protocols*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*understand the use of Big Data and cyber threads on Industry 4.0*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*recognize the uses of cloud computing and data analytics*	*1*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*familiar with the techniques used in Digital manufacturing system*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*acquire knowledge on the use of IOT, cloud computing and Industry 4.0 technologies*	*1*	-	-	-	-	*3*	*2*	-	-	-	-	-	-	*2*	-

Unit-1 - IoT in Industrial Revolution ***9 Hour***

Introduction to Industry 4.0 - Digitalization and the networked economy - Basics of Internet of Things (IOT) and Network protocol - IOT Architecture and its standards - Industry Internet of Things (IIOT) - Need of sustainability assessment of Industries – Lean Production and Smart factory - Introduction to sensors and actuators – Next generation sensors.

Unit-2 - Bigdata and Cyber Security In Industry 4.0 ***9 Hour***

Cyber Physical Systems (CPS) – Features - Role of AI in Industry 4.0 - Need of Big Data in IIOT - Big Data analytics – Data Science in IIOT and Data centred network - Data management using Hadoop - Cyber security in Industry 4.0 - Components - Threats and Awareness - Security issues within Industry 4.0 network.

Unit-3 - Cloud Computing for IoT ***9 Hour***

Introduction to Cloud computing - Cloud computing service options - Cloud deployment models - Cloud virtualization - Types of Hypervisors - Fog computing architecture in IIOT - Cloud 9marketplace and Cloud providers - IOT Gateway, IOT Edge, and its programming

Unit-4 - Digital Manufacturing ***9 Hour***

Introduction to Digital manufacturing - Architecture of Digital manufacturing - Digital Twin technology for smart manufacturing system – Road map to success in Digital Manufacturing -Identification of current situation in Industry – Perform Self-study – attain future goal with in Digital Manufacturing and Design (DMD).model – Intelligent Machining - concept, elements and benefits.

Unit-5 - Applications and Case Studies ***9 Hour***

Application: Assembly sectors in Factories, Inventory and Quality control in Industries, Industrial security and Safety Management and Health care sectors. Case Study: Processing and packing industries and Automobile manufacturing sectors.

Learning Resources	1. *Sudip Misra, Chandana Roy, Anandarup Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", CRC press, ISBN 9781032146751.* 2. *Hamilton Ortiz J, editor. Industry 4.0 - Current Status and Future Trends. 2020 Mar 25; Available from: http://dx.doi.org/10.5772/intechopen.86000.* 3. *Cheng FT, editor. Industry 4.1: Intelligent Manufacturing with Zero Defects. John Wiley & Sons; 2021.*	4. *Bernabe JB, Skarmeta A. introducing the challenges in cybersecurity and privacy: The european research landscape. InChallenges in Cybersecurity and Privacy-the European Research Landscape 2022. River Publishers.* 5. *Buyya R, Srirama SN, editors. Fog and edge computing: principles and paradigms. John Wiley & Sons; 2019.* 6. *Kurfess TR, Saldana C, Saleeby K, Dezfouli MP. A review of modern communication technologies for digital manufacturing processes in industry 4.0. Journal of Manufacturing Science and Engineering. 2021.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Muthumanikam, Jt. Director, CVRD, Avadi, Chennai*	1. *Dr, A. Suresh Babu, Associate Professor, Manufacturing, Anna University, Chennai*	1. *Dr. T. Rajasekeran, SRMIST*
2. *Mr. S. Bhargav, General Manager, operations, Rane Brakes Lining LTD, chennai.*	2. *Dr.V. Srinivasan, Associate Professor, Annamalai University, Chidamabaram*	2. *Dr. A. Arul Jeya Kumar, SRMIST*

ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 17C
(Syllabi for Mechanical Engineering (Automation and Robotics) Programme Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Elective

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MEE361J	Course Name	PLC AND VIRTUAL INSTRUMENTATION	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	*Mechanical Engineering*	*Data Book / Codes / Standards*	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*acquire the concepts of PLCs and their hardware components*
CLR-2 :	*explore the PLC Programming Language and its features*
CLR-3 :	*develop knowledge of PLC data handling and math instructions*
CLR-4 :	*acquire the concepts of virtual instrumentation*
CLR-5 :	*acquire knowledge on Data acquisition systems and its components*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the PLC and its hardware components*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*demonstrate the PLC programming skills for real-world problem solving*	-	*3*	-	-	*1*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*operate various data and math functions*	-	*3*	-	-	*1*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*differentiate the importance of various virtual instrumentation*	-	-	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*use various virtual instrumentation components for data acquisition*	-	-	-	-	*2*	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - PLC Introduction	***12 Hour***
Introduction to Hardwired Relay Logic and Solid-state Logic, Introduction to PLC, Evolution of PLC, Role of PLC in an Industrial Automation, Advantage of a PLC, PLC Architecture, The I/O section, Analog and Discrete I/O Modules, Special I/O Modules and I/O Specifications, PLC size & Application, PLCs versus Computers, The CPU and Memory Design, Memory types and programming devices, Recording and retrieving data and PLC workstations. SCADA System *Lab 1: PLC I/O wiring Methods and Programming the PLC via Ladder Logic; Lab 2: Implementation of Timer, Logic Gates and Counter; Lab 3: Motor Control with Interlocks*	
Unit-2 - PLC Programming	***12 Hour***
Introduction to PLC Programming Languages, Ladder Diagram (LD), Functional Block Diagram (FBD), Sequential Function Charts (SFC), Instruction List (IL), Structures Text (ST), Relay Logic Instructions, Ladder Logic Instructions, Programming for Gates, Flow Charting as a programming method, Programming of Timers, ON delay, OFF delay, Retentive Timers, PLC timer functions, Programming Counters, Up/down counters, Combining counter, Math and Program Control Instructions, IEC 611313-3 Standard Building Blocks. Lab 4: Water Level Control System; 5: HMI Integration; Lab; Lab 6: Fault Diagnosis and Handling	
Unit-3 - PLC Data Handling and Math Instructions	***12 Hour***
Data manipulation and data transfer operations, data compare instructions and data manipulation programs, Numerical data I/O interfaces and Set-point control, Math Instructions – Addition, Subtraction, Multiplication and Division instructions, File Arithmetic Operations, Sequencer and Sequencer Instructions, Sequencer Programs, Shift Register Instructions. Lab 7: Density-Based Traffic Light Control System; Lab 8: Lift Control System; Lab 9: Advanced Process Simulation	
Unit-4 - Introduction to Virtual Instrumentation	***12 Hour***

Introduction and Evolution of virtual instrumentation, Conventional and distributed virtual instrumentation. Introduction and Advantages of LabVIEW, Front panel, back panel representations, Block diagram, Menus, Palettes, VI and Sub VI, Editing and Debugging VI, Structures, Arrays, Clusters, Charts and Graphs, Feedback Nodes, Formula Nodes, Local and Global Variable, File Input/Output and String Handling. Lab10: Setting up Digital Potentiometer for Industrial Application; Lab 11: Digital Compass and Gyroscope for Measurements; Lab 12: Setting up Digital Accelerometer with LCD Character Display for Measurements
Unit-5 - Data Acquisition in Virtual Instrumentation ***12 Hour***
Data Acquisition with LabVIEW, Transducers, Signals, Signal Conditioning, DAQ Hardware Configuration, DAQ Hardware, Analog inputs, Analog outputs, Counters, Digital I/O, DAQ Software architecture, DAQ assistant, Interfacing with Assistants, Interfacing Instruments. Lab 13: Sense Distance through IR and Sonic Range Finder; Lab 14: Pattern Display through LED Matrix and use of EEPROM; Lab 15: Temperature Measurement through Sensor and use of Digital Thermistor

Learning Resources	1. *Frank D. Petruzella, Programmable Logic Controllers. McGraw Hill, 5th Edition, 2019* 2. *Bolton, W, Programmable Logic Controllers. Elsevier Newnes, 6th Edition, 2015* 3. *John W. Webb, Ronald A. Reis, Programmable Logic Controllers: Principles and Applications, Pearson, 5th Edition, 2015* 4. *Madhuchhanda Mitra and Samarjit Sen Gupta, Programmable Logic Controllers and Industrial Automation: An Introduction. Penram International Publication (India), 2nd Edition, 2017*	*5. Sanjay Gupta and Joseph John, Virtual Instrumentation using LabVIEW: Principles and Practices of Graphical Programming. Second Edition, McGraw Hill, 2nd Edition, 2015* *6. Jeffrey Y. Beyon, LabVIEW Programming, Data Acquisition and Analysis, Prentice Hall PTR, 2000.* *7. Jovitha Jerome, Virtual Instrumentation using LabVIEW, PHI Learning Private Limited, 2010*

Learning Assessment

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability, Chengalpattu, Tamil Nadu	*1.Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	*1. Dr. S. Murali, SRMIST*
2. Mr. N. Parameswaran, Manager-Production Engineering at Nokia Solutions and Networks Pvt Ltd Chengalpattu, India	*2. Prof. Robert Richardson, University of Leeds, UK.*	*2. Dr. S. Prabhu, SRMIST*

Course Code	21MEE362T	Course Name	MECHATRONICS FOR AUTOMATION AND ROBOTICS	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	*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 key elements of mechatronics systems*
CLR-2 :	*apply the knowledge on sensors and signal conditioning*
CLR-3 :	*be familiar with the working and selection of drives, actuators and controls for automation*
CLR-4 :	*be familiar with the mechatronics systems in robotics*
CLR-5 :	*be familiar with applications of mechatronics-based systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*differentiate the basic key elements of mechatronics systems*	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-2:	*apply the various sensors and signal conditioning process in mechatronics systems*	-	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*differentiate and utilize drives and control systems to be used in automation*	-	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*differentiate and utilize sensors and end effectors to be used in robots*	-	3	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*apply the knowledge on mechatronics-based application*	-	3	2	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 – Introduction to Mechatronics	***9 Hour***
Introduction to Mechatronics system- Mechatronics system components and Measurement Systems, Control Systems-Open and Closed Loop System. Transfer function: Laplace transform, system in series and System with feedback loop. Sequential Controllers, MEMS	
Unit-2 - Sensors and Signal Conditioning	***9 Hour***
Introduction to Sensors and Transducers, Sensor Classification. Electric position sensors- limit switches, Photoelectric sensors- principles, types, applications. Proximity sensors- Inductive, capacitive, Magnetic sensors. Digital Encoders: Principle, Absolute and Incremental Encoders. Signal Conditioning- Operational amplifier, A/D and D/A converters. Signal processing, Multiplexer and Introduction to Data acquisition system.	
Unit-3 - Drives, Actuators and Controls for Automation	***9 Hour***
Electrical Drives- DC, AC and Stepper Motors. Piezoelectric Actuators, Fluid Power Actuators- Linear and Rotary. Proportional, Integral, Derivative and PID controller. PLC- Basic structure, Input and Output Modules, Mnemonics for programming, Latching and Internal relays, Timers, Counters and Shift Registers, Program using Ladder diagram.	
Unit-4 - Mechatronics Systems in Robotics	***9 Hour***
Introduction to robotics, End effectors- types, Mechanical grippers, Robot/ end effector interface. Robotic sensors- tactile, proximity and range sensors, need for sensors in robotics. Robot vision, Position and velocity control in robots.	
Unit-5 - Automation and Robotics: Industrial Applications	***9 Hour***
Automated inspection, Car park barriers using PLC, robots for - shape, size and color sorting. Robots used in welding, painting, additive manufacturing, agriculture and health monitoring applications.	

Learning Resources	1. Bolton.W, "Mechatronics", Addison Wesley, 4th Edition, New Delhi, 2010. 2. Mikell P. Groover "Industrial Robotics: Technology, Programming, and Applications" McGraw-Hill, 1986	3. Jacob Fraden, "Handbook of Modern Sensors Physics, Designs, and Applications", Third Edition, Springer-Verlag New York, 2004 4. Anthony Esposito, "Fluid Power with applications", Pearson Education Inc, 2015. 5. Soloman S. Sensors and control systems in manufacturing. McGraw-Hill Education; 2010.

Learning Assessment

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. G.M. Kumaravel, Brakes India Ltd	1.Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in	1. Dr. R. Murugesan, SRMIST
2.Dr. S Rajkumar, Rane Engine Valve Ltd	2. Prof. Robert Richardson, University of Leeds, UK.	2. Dr. M. Prakash, SRMIST
3.Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability		

Course Code	21MEE363T	Course Name	INDUSTRIAL INTERNET OF THINGS	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	*Mechanical Engineering*	***Data Book / Codes / Standards***		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*familiarize the concept of IIoT*
CLR-2 :	*acquire knowledge on the structure of IIoT*
CLR-3 :	*understand the principles of CPS and CMS in manufacturing*
CLR-4 :	*familiar with method and new frameworks of information security management.*
CLR-5 :	*analyze the areas where IIoT can be employed*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*knowing the purpose of IIoT in engineering*	*1*	-	*2*	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*explore the framework of IIoT in industry*	*2*	-	*2*	-	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*determine the work scenario of cyber based manufacturing*	*1*	-	*2*	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*explain the concept of information cyber security syndrome*	-	-	*1*	-	*2*	-	-	*1*	-	-	-	-	*2*	-	-
CO-5:	*learn the application of IIoT in manufacturing Industries*	*1*	-	*2*	-	*2*	-	-	-	-	-	-	-	*2*	-	-

Unit-1: Introduction	***9 Hour***
Introduction to IoT – IoT Background-History and definition - IoT vs IIoT - Innovation and IIoT - Industrial Internet of Things and Cyber Manufacturing Systems - Role of Internet of Things (IoT) and Industrial Internet of Things (IIoT) in Industry - Key terms of IoT–IoT Platform, Interfaces, API, clouds - Data Management Analytics - Challenges of IIoT.	
Unit-2: Architectures and Components	***9 Hour***
Various Architectures of IoT and IIoT - Fundamentals of Control System - Introduction to Sensors - Types of sensors, working principle of basic Sensors - Ultrasonic Sensor, IR sensor, Sensors, and Actuators for Industrial Processes - Sensor networks - Process automation and Data Acquisitions on IoT Platform - Implementation Viewpoint - Architectural Topology - Three Tier Topology.	
Unit-3: Modeling of CPS and CMS	***9 Hour***
CPS - Cyber Manufacturing Systems - Cyber Physical Electronics production - Modelling of Cyber Physical Engineering and manufacturing - Model based engineering of supervisory controllers for cyber physical systems - Next Generation Sensors - Collaborative Platform and Product Lifecycle Management - Augmented Reality and Virtual Reality – Big Data and Advanced Analysis.	
Unit-4: Cyber Security	***9 Hour***
Introduction to web security - Vulnerabilities of IoT - Security and ethical requirements - IIoT security - Data storage on cloud-based platforms - Risks and challenges - Working of IoT devices - Potential Solutions for Security Vulnerabilities - Security with IIoT Insights from Steel Industries, Health Industries, Smart Cities, Smart factories, etc.	
Unit-5: Application and Case Studies of IIoT Systems	***9 Hour***
IIoT application development with Embedded PC based development boards - Operating systems and Edge development board - Smart Metering - e-Health Body Area Networks - City Automation - Automotive - Development of mini-Project - Applications - Home Automation - Smart Cards - Plant Automation - Real life examples of IIOT in Manufacturing Sector.	

Learning Resources	*1. The Internet of Things in the Industrial Sector, Mahmood, Zaigham.Springer, 2019* *2. Peter Waher, 'Mastering Internet of Things', Packt Publishing, 2018.* *3. Sabina Jeschke, Christian Brecher Houbing Song , Danda B. Rawat Editors Industrial Internet of Things Cyber Manufacturing Systems, 2016*	*4. Security and Privacy Trends in the Industrial Internet of Things, Cristina Alcaraz, Springer, 2019.* *5. The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2nd Edition,Willy Publications*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Bhargav, Rane brakes, Chennai	*1. Dr. A. A. Brazilraj, DIAT, Pune*	*1. Dr. A. Arul Jeya Kumar, SRMIST*
2. Mr. Brijesh, Rotexepoxy, Chennai	*2. Dr. V. Srinivasan, Annamalai University*	*2. Dr. M. Prakash, SRMIST*
3.Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability	*3.Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	

Course Code	21MEE364T	Course Name	ADVANCED AUTOMATION SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*apply the principle of automation and various equipment and systems that are used in the industry*
CLR-2 :	*recognize the use of automated systems in Monitoring system*
CLR-3 :	*determine the concepts of Automation in Detroit and material handling system*
CLR-4 :	*study of flexible manufacturing systems*
CLR-5 :	*apply the principles of machine learning and AI for practical applications.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*demonstrate the principle of automation and systems that are used in the industry.*	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*discuss the idea of vision based Monitoring systems utilize for automation*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*summarize the various methods of automation in Detroit and material handling system*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*study group technology, types of coding systems and FMS*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*illustrate the concepts of machine learning and AI for Automation*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1: Introduction to Automation ***9 Hour***

Importance of automation in the manufacturing industry - Basic elements of Automation, Automation Principles and Strategies, Functions, Level - Process Industries and Discrete Manufacturing Industries, Applications, Design of an automated system - Building blocks of an automated system, working principle and examples - Fabrication or selection of various components of an automated system – Sensors used in an automated system , construction and principle of operation – Microprocessor technology: signal conditioning, data acquisition, use of microprocessor or micro controllers, configurations, working.

Unit-2: Vision based Monitoring System ***9 Hour***

Production Monitoring System–- Inspection – types - Automated Inspection - Principles and Methods – Quantitative Analysis of Inspection - case-studies. Coordinate Measuring Machines - components, Construction, Operation and Programming, software, Applications and Benefits, Flexible Inspection Systems, Inspection Probes on Machine Tools, Other Contact Inspection Methods, Machine Vision - types, principle, Basic functions, Edge Detection algorithm, role in industrial robotics and Other optical Inspection Methods. Product identification system: Barcode, RFID etc

Unit-3: Automation in Detroit and Material Handling Systems ***9 Hour***

Automated Flow lines, Methods of Work-part Transport, Transfer Mechanism, Buffer Storage, Control Functions, and Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines, Transfer Lines Without Storage, Partial Automation, Automated Flow Lines with Storage, Computer Simulation of Automated Flow Lines. Material handling in the production system - principles - automated guided vehicle system (AGVS), Wi-Fi-enabled AGVS, Conveyor systems, Cranes and Hoists. Storage systems – AS/RS, Carousel system, Identification and tracking systems - Interfacing Handling and Storage with Manufacturing

Unit-4: Flexible Manufacturing Systems ***9 Hour***

Group technology - Visual Inspection, classification and coding, Production flow analysis - case study, FMS, Objective, need ,Components and types, Applications, Benefits and limitations, planning and Implementation Issues, Quantitative Analysis of Flexible Manufacturing Systems, Simple example of FMS planning for Automobile plant., Different FMS software's, General structure and Requirements for FMS software , Functional descriptions and operational overview advantages, FMS application in Machining, sheet metal fabrication

Unit-5: Artificial Intelligence and Machine Learning in Automation ***9 Hou***

Definition, knowledge representation techniques, problem solving, search techniques, game playing, knowledge and logic, learning methods, Case studies of typical applications in tool selection, process selection, part classification, inventory control, process planning, etc. Introduction to machine learning, Role of machine learning in Industrial Automation, Inspection Using Machine Learning/Artificial Intelligence - case-studies. Impact of AI & Machine learning in manufacturing Industry, digital twin in manufacturing - Applications of Digital Twin Technology in Smart Manufacturing

Learning Resources	*1. Mikell P. Groover, "Automation Production systems and Computer Integrated manufacturing", Fourth edition, prentice hall of India, New Delhi, 2016.* *2. Boltan, W., Mechatronics: electronic control systems in mechanical and electrical engineering, Longman, Singapore, 1999.* *3.HMT Ltd. Mechatronics, Tata McGraw-Hill, New Delhi, 1988.* *4. David J. Parrish, "Flexible Manufacturing", Butterworth-Heinemann, Newton, MA, USA, 1990.* *5. Richard D. Klafter, Thomas. A, Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009* *6. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics,Prentice Hall Inc., 1987*	*7. "An Introduction to Automated Process Planning Systems" – Tiess Chiu Chang & Richard A. Wysk* *8."Anatomy of Automation" – Amber G.H & P.S. Amber, PrenticeHall.* *9.Peterson "Introduction to Artificial Intelligence and expert system (PHI)* *10. Vinod Chandra S.S., Anand Hareendran S, "Artificial Intelligence and Machine Learning", 2014.* *11.Ethem Alpaydin,"Introduction to Machine Learning, MIT Press, Prentice Hall of India, Third Edition 2014.* *12.Padhy, N. P., Artificial Intelligence and Intelligent Systems, Oxford University Press, New Delhi* *13.Stuart Russel and Peter Norvig, "Artificial Intelligence: A Modern Approach", Fourth Edition, Pearson Education, 2020.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1.Dr. Srinivasan Palanisamy, Principal Engineer - E&E, Mahindra & Mahindra Ltd.	*1.Dr. N. Arunachalam, Associate Professor, IIT Madras*	*1.Dr.S. Oliver Nesa Raj, SRMIST*
2. Dr. S Rajkumar, Rane Engine Valve Ltd	*2. Prof. Robert Richardson, University of Leeds, UK*	*2. Dr. A. Vijaya, SRM IST*
3.Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability	*3.Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	

Course Code	21MEE365T	Course Name	ROBOT 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	*Mechanical Engineering*	***Data Book / Codes / Standards***	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basic terminologies and concepts associated with Robotics*
CLR-2:	*be familiar with the robotic control system, actuators, and End effectors*
CLR-3:	*control both the position and orientation of the tool in the three-dimensional space*
CLR-4:	*be familiar with the concept of forward and inverse kinematic to model the kinematic equations of the robot*
CLR-5:	*understand robot cell design and its control*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the basic terminologies and concepts associated with Robotics and end effectors*	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*acquire the knowledge about robot actuators, End effectors and control system*	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*find the relationship between the joint variables and the position and the orientation of the tool.*	3	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*apply transformations to obtain forward and Inverse kinematics equation of robot manipulators.*	-	2	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*apply the concepts of Robot Cell Design, Control and safety considerations in the real time modelling.*	-	2	3	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1: Introduction	***9 Hour***
Basic components of Robot, Accuracy and repeatability of Robotics, Robot joints and links, Robot Classifications, Work volume, Serial manipulators, Parallel Manipulators, Types of Mobile Robots	
Unit-2: Drives and Controls in Robots	***9 Hour***
Robot Drive systems - Characteristics, Types - Electric, Pneumatic and Hydraulic. Types of grippers, Gripper force analysis - Gripper design - Numerical Problems, Robot Control- Control of the Robot in Internal and External Coordinates	
Unit-3: Robot Coordinate Systems	***9 Hour***
Introduction to transformation, position and orientation of objects, objects coordinate frame, Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates - Numerical Problems	
Unit-4: Forward and Inverse Kinematics of Robot	***9 Hour***
Link and joint coordinates for D-H representation, Kinematic relationship between adjacent Links, Direct Kinematics of 3 - DOF manipulator - Spherical arm, Cylindrical Arm, Articulated Arm, RPY Wrist, Inverse Kinematics of transformation, General properties of solution, Inverse kinematics – 3 DOF manipulator.	
Unit-5: Robot Work Cell Design	***9 Hour***
Robot cell layout, considerations in workcell design, workcell control, Interlocks, Error Detection and Recovery, Workcell Controller, Robot Cycle Time Analysis, Safety in Robotics - Design Considerations for Safety, Safety Sensors and Safety Monitoring	

Learning Resources	1.Mihelj, Matjaž, et al. Robotics. Springer, Cham, 2019. 2. Niku, Saeed B. Introduction to robotics: analysis, control, applications. John Wiley & Sons, 2020. 3. Bruno Siciliano, et al. Robotics Modelling, Planning and Control, Springer, 2009	4. Angeles, Jorge, ed. Fundamentals of robotic mechanical systems: theory, methods, and algorithms. New York, NY: Springer New York, 2003.

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1.Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability	*1. Prof. Robert Richardson, University of Leeds, UK*	*1. Dr. J. Daniel Glad Stephen, SRMIST*
2.Mr. Ponmurugaraj, ZF Commercial vehicle control systems limited, Chennai	*2. Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	*2. Dr. S. Prabhu, SRMIST*

Course Code	21MEE366T	Course Name	ROBOT MECHANICS AND CONTROL	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	*Mechanical Engineering*	***Data Book / Codes / Standards***		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concepts of robot mechanisms and co-ordinate transformations*
CLR-2:	*apply forward and inverse kinematics to manipulators*
CLR-3:	*apply dynamics to manipulators*
CLR-4:	*understand the concepts of trajectory planning for manipulators*
CLR-5:	*understand the concepts of Motion control for manipulators*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*determine co-ordinate transformations*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	*1*	-
CO-2:	*solve forward and inverse kinematics*	-	*3*	-	*3*	*2*	-	-	-	-	-	-	-	*3*	*1*	-
CO-3:	*obtain the manipulator equations of motion using dynamics*	-	*3*	-	-	*2*	-	-	-	-	-	-	-	*3*	*1*	-
CO-4:	*apply trajectory planning using different methods*	-	*2*	-	*3*	*2*	-	-	-	-	-	-	-	*3*	*1*	-
CO-5:	*apply motion control of manipulators*	-	*2*	-	-	*2*	-	-	-	-	-	-	-	*3*	*1*	-

Unit-1: Configuration Space and Rigid Body Motions	***9 Hour***
Degrees of freedom of Robot, Grublers formula, Configuration space: Topology and Representation, Constraints, Description of position and orientation, Transformations and homogenous transformation matrix, Rotations and Angular velocities transformation	
Unit-2: Forward and Inverse Kinematics	***9 Hour***
Kinematic parameters, Different notations, DH representation, Product of Exponentials representation, Forward kinematics for position and orientation, Velocity kinematics, Manipulator Jacobian, Overview of analytic inverse kinematics, Inverse kinematics based on numerical methods, Simulations using appropriate software	
Unit-3: Manipulator Dynamics	***9 Hour***
Introduction to Robot dynamics, Equation of motion in state space form, Lagrangian dynamics, Newton-Euler dynamics, Overview of inverse dynamics, Simulation using appropriate software	
Unit-4: Trajectory Planning	***9 Hour***
Path and Trajectory, Trajectory planning using smooth functions, Joint space trajectory planning, Cartesian space trajectory planning, Path-Planning Algorithms: Grid-based algorithms, Sampling based algorithms, Simulations using appropriate software.	
Unit-5: Robot Motion Control	***9 Hour***
Overview of motion control, Types of robot manipulator control, Kinematic control: motion control with velocity input, motion control with torque or force input, Dynamic control: schemes, simulations, overview of hybrid motion-force control, simulations using appropriate software	

Learning Resources	*1. . Kevin M. Lynch and Frank C. Park, Modern Robotics: Mechanics, Planning and Control, Cambridge University Press, 2017.* *2. Santhakumar Mohan, Mechanics and Control of Robotic Manipultors, NPTEL Course: IIT Palakkad.* *3. Mark W. Spong and M. Vidyasagar, Robot Dynamics and control, John Wiley and Sons, 2008* *4. Mittal and Nagrath, Robotics and Control, Tata McGraw-Hill, 2003.* *5. Robert J. Schilling, Fundamentals of Robotic Analysis and Control, Prentice Hall of India Pvt. Ltd., 2003.* *6. John J. Craig, Introduction to Robotics Mechanics and Control, Fourth Edition, Pearson Education International, 2018.*	*4. 7. Bruno Siciliano, Lorenzo Sciavicco, Liuigi Villani and Giuseppe Oriolo, Robotics: Modelling, Planning and Control, Springer, 2009.* *8. Miomir Vukobratovic, Introduction to Robotics, Springer-Verlag, 1989.* *9. K. R. Guruprasad, Robotics: Mechanics and Control, Prentice Hall India Pvt. Ltd., 2020.* *10. Peter Corke, Robotics, vision and control (Fundamental algorithms in matlab), Springer, 2017.* *11. Steven M. Lavalle, Planning Algorithms, Cambridge university press, 2006.* *12. Matthew T. Mason, Mechanics of Robotic Manipulation, MIT Press, 2001.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. G.M. Kumaravel/ Brakes India Ltd	*1. Prof. Robert Richardson, University of Leeds, UK*	*1. Dr. Shravankumar, SRMIST*
2. Dr. S Rajkumar, Rane Engine Valve Ltd	*2.Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	*2. Dr. S. Prabhu, SRM IST*
3.Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability		

Course Code	21MEE367T	Course Name	SOFT ROBOTS	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	*Mechanical Engineering*	***Data Book / Codes / Standards***		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the fundamental concepts of Soft Robotics*
CLR-2:	*be familiar with modeling and control of soft robot*
CLR-3:	*be familiar with the concepts of soft actuators*
CLR-4:	*be familiar with the concepts of soft sensors*
CLR-5:	*utilize the Soft Robot in different applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the fundamental concepts and material selections for soft robots*	-	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*demonstrate the manufacturing principles and control of soft robot*	-	-	*3*	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*evaluate and analyze the transformation of different soft end effectors*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze various sensing capabilities of soft robot*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*construct soft robot for various industrial applications*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1: Introduction and Soft Materials	***9 Hour***
Introduction to Soft Robotics - Definition, types and recent developments-biological analogy- Silicon Elastomers and moulding, Thermoplastics and textiles	
Unit-2: Modelling and Control	***9 Hour***
Mathematical Modeling and physics of soft bodies-soft robot architectures- Control of soft robot, fluidic PID control - soft materials gel-Manufacturing methods, Silicone mould, 3D printing and fabric welding methods	
Unit-3: Soft Actuators	***9 Hour***
Artificial muscles, peristaltic robotics, soft pneumatic robotics, Soft artificial muscle, fluid-embedded elastomers, and particle jamming, Jamming mechanisms. Cable driven soft robots- Shape memory alloys, Additional actuation strategies-Kinematics relationship of soft actuators	
Unit-4: Soft Sensors	***9 Hour***
Soft resistive, capacitive, and inductive sensing, Soft optical and ionic sensing- Embed sensing capabilities and conductive elements in soft structures- soft sensor for strain, force and contact	
Unit-5: Soft Robot Applications	***9 Hour***
Soft robotics in rehabilitation and Healthcare applications, Food and Agriculture- E-Textiles- Wearable Soft Robots- locomotion robots-Soft gripper applications	

Learning Resources	*1. Gareth J. Monkman, "Soft Robotics", Bentham Books, 2022, ISBN: 978-981-5051-73-5* *2. Ali Shafti & Ali Shiva, "Soft and Stiffness-controllable Robotics Solutions EUROSPAN GROUP, 2018* *3. Matthew Borgatti, "Soft Robotics: A DIY Introduction to Squishy, Stretchy, and Flexible Robots", Make Community, 2018* *4. Klafter.R.D, Chmielewski.T.A and Noggins, "Robot Engineering: An Integrated Approach", Prentice Hal of India Pvt. Ltd., New Delhi, 2010.* *5. Amir Jafari and Nafiseh Ebrahimi, "Soft Robotics in Rehabilitation",1st Edition, Academic Press, 2021. ISBN:0128185384*	*6. Shane Xie, Mingming Zhang and Wei Meng, "Soft Robots for Healthcare Applications: Design, modelling, and control (Healthcare Technologies)", 1st Edition, The Institution of Engineering and Technology,2017, ISBN-10:1785613111* *7. https://softroboticstoolkit.com/* *8. Zion Tsz Ho Tse, Yue Chen,Sierra Hovet, Hongliang Ren, Kevin Cleary, Sheng Xu, Bradford Wood, and Reza Monfaredi, "Soft Robotics in Medical Applications", Journal of Medical Robotics Research, Vol. 03, No. 03n04, 1841006 (2018) https://doi.org/10.1142/S2424905X18410064* *9. Alexander Verl, Alin Albu-Schäffer,Oliver Brock Annika Raatz, "Soft Robotics", Transferring Theory to Application, springer, 2015,ISBN 978-3-662-44506-8*

Learning Assessment

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.S.Prabhu Shankar, DXC Technologies, Chennai	*1. Dr. N.Arunachalam, Associate Professor, IIT Madras*	*1.Prof.S.Prabhu, SRMIST*
2. Dr. S Rajkumar, Rane Engine Valve Ltd	*2.Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	*2.Mr.V.Manojkumar, SRMIST*
3.Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability		

Course Code	21MEE368T	Course Name	AUTONOMOUS ROBOT VEHICLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	design and kinematic modeling of mobile robots
CLR-2:	explore the control algorithms
CLR-3:	demonstrate the various sensors
CLR-4:	explore the with localization, planning and navigation
CLR-5:	develop mobile robot and its control

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	design and kinematic modeling of mobile robots and wheels	-	2	3		-	-	-	-	-	-	-	-	-	1	-
CO-2:	apply the control algorithms involved in mobile robots	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	familiar with sensors used for perception		3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	explore algorithms in localizations	-	2	2	-		-	-	-	-	-	-	-	3	-	-
CO-5:	select the path planning and navigation	-	-	2	1	-	-	-	-	-	-	-	-	3	-	-

Unit-1: Introduction to Mobile Robots — **9 Hour**

Introduction to Mobile robots, Locomotion-Classification -Legged, hopping -Wheeled, Aerial-Tutorial on different robotic structure and wheel types-Key issues in locomotion, Degree of mobility and steerability, robot maneuverability-Mobile Robot Kinematics -Kinematic model , Forward Kinematic model-Wheel kinematic constraints-Motion control, Kinematic models of simple car and legged robots

Unit-2: Control of Mobile Robots — **9 Hour**

Control theory, Control design basics-Cruise-Controllers-Performance Objectives-Tutorial on control theory -State space modelling of mobile robot-Linearization –Linear Time-Invariant (LTI) system , Stability-PID control, basic control algorithms-Low-level, control. state space control, back stepping control

Unit-3: Perception — **9 Hour**

Sensors for mobile robots-Classification, performance, uncertainty in sensors-Wheel sensor, Heading sensor -Accelerometer, Inertial measurement -Motion sensor, range sensors-Global positioning system (GPS), Doppler effect-based sensors-Vision sensor, Basics of computer vision-Image processing techniques, Feature extraction – Image Range data location recognition

Unit-4: Localization — **9 Hour**

Major challenges-localization based navigation-Belief representation, Map representation- Probabilistic Map, Examples of localization systems-Autonomous map building-Odometric position estimation-Markov localization, Bayesian localization, Kalman Localization-Positioning beacon systems-Tutorial on mobile robot localization

Unit-5: Planning and Navigation — **9 Hour**

Planning and Reaction-Path Planning -Graph search, D algorithm, Potential field. Obstacle avoidance, A* algorithm, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), Rapidly-exploring random tree (RRT)- Bug algorithm, bug-01 and bug-02,Histogram, Curvature velocity techniques.- Tutorial - Simulation of path planning using suitable software*

Learning Resources	*1. Siciliano. et al, "Robotics: Modelling, Planning and Control", 3rd Edition, Springer, 2009.* *2. Choset. et al, "Principles of Robot Motion: Theory, Algorithm & Implementations", MIT Press, 2005.* *3. Thrun, Burgard, Fox, "Probabilistic Robotics", MIT Press, 2005.*	*4. Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", MIT Press, 2011.* *5.Siciliano, Khatib, Eds, "Handbook of Robotics", Springer, 2008.* *George A. Bekey "Autonomous Robots" MIT Press.* *6. S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. S Rajkumar, Rane Engine Valve Ltd	*1. Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	*1. Dr. A. Vijaya, SRM IST*
2.Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability	*2. Prof. Robert Richardson, University of Leeds, UK.*	*2. Dr. Oliver Nesa Raj, SRM IST*

Course Code	21MEE369J	Course Name	ROBOT APPLICATIONS AND PROGRAMMING	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	*Mechanical Engineering*	**Data Book / Codes/Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*study about the basics of robot programming and VAL language*
CLR-2:	*understand the architecture and configuration of industrial robotic controller*
CLR-3:	*be familiar with RAPID programming language, its features, and applications*
CLR-4:	*comprehend the ROS based scripting and programming*
CLR-5:	*acquire knowledge on the practical study of robot programming*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand robot controller, operating modes, robot programming for different applications using VAL language*		-	*2*	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*configure different modules of industrial robotic controller*		-	*2*	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*demonstrate different robot operations and RAPID language commands, functions, and interrupts*		-	*2*	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*implement robotic solutions using ROS scripting and Programming*		-	*2*	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*analyze robots programming using Industrial robot applications*		-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	*2*

Unit-1: Basics of Robot Programming ***12 Hour***

Robot programming Introduction Types Manual programming - Walk through programming - Offline programming - Lead through programming , Coordinate systems of Robot, Robot controller- major components, Interpolation-Interlock commands- Operating mode of robot, Jogging Types, Robot Languages-Classifications, Structures- VAL language commands, motion control, hand control, program control, VAL-II programming, basic commands, Lab1:Pick and place object using manual mode, Lab2: Creating Program elements using Motion, Position and Speed, Lab3: Creating Program elements using Numeric registers and Position Registers.

Unit-2: Rapid Language using Robot Studio ***12 Hour***

Introduction to Robot studio, RAPID language basic commands, Motion Instructions, Pick and place operation using Industrial robot, Programming using linear and joint interpolations, manual mode, automatic mode, Subroutine, interrupts, Functions, error handlers, system i/o interrupts and TRAP routines, command-based programming, Move master command language- Programming using automatic mode. Lab4: Creating Path optimization using Virtual Flex pendant in Robot studio, Lab5: Creating Program elements using Sub-routines using Inputs and Outputs

Unit-3: Industrial Robotic Controller ***12 Hour***

Architecture of fifth generation industrial robot controller, Memory mapping and layout, Hardware and software setup, Standard i/o configuration, Configuration of Digital i/o modules, Programming robot In manual mode using i/o commands, Interfacing and programming i/o for Robot controller, Communication types, Profinet configuration – communication module, Safety and configuration aspects of controller, DX-581 SIGNAL configuration, Lab6: Creating Program elements using Inputs and Outputs, Lab7:Collision detection and avoidance Strategies

Unit-4: Robot Operating System ***12 Hour***

ROS Essentials and Architecture - ROS Topics, Services, Actions and Nodes, ROS Workspace and Packages, ROS Build System- Catkin and CMake, ROS Communication- Publisher & Subscriber model- Service and Client model, Unified Robot Description Format, ROS Actions- action interface - action servers and clients ROS Navigation Stack, Lab8: Simple Program using turtle, Lab9: Map creation with Gazebo and RViz.

Unit-5: Robot Applications	***12 Hour***
Pick and Place applications, Palletizing applications, Robot welding application, Production rate calculations using robot, Conveyor Tracking, PLC master control programming, HMI Programming and screen developing for robot start/ stop, Maintenance controls. Lab10. Pick and place operation Using VREP, Lab11: Vision based robot for palletizing operation Using Parallel Manipulator Lab12: FMS Cell based robot Programming using 6 axis robots	

Learning Resources	*1. Deb. S. R. "Robotics Technology and Flexible Automation", Tata McGraw Hill publishing company limited, 1994* *2. Mikell. P. Groover, "Industrial Robotics Technology", Programming and Applications, McGraw Hill Co, 1995.* *3. Klafter. R.D, Chmielewski.T.A and Noggin's, "Robot Engineering: An Integrated Approach", Prentice Hall of India Pvt. Ltd., 1994.*	*4. Fu .K. S, Gonzalez .R. C. & Lee .C.S.G, "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book co, 1987.* *5. Quigley .M, Gerkey. B & William. D, "Programming Robots with ROS: A Practical Introduction to the Robot Operating", O'Reilly Media, Inc., 2015.* *6. Joseph. L, "ROS Robotics Projects", Packt Publishing, 2021.* *7. ABB Robotics, "Operating manual Robot studio 5.14" Document ID: 3HAC032104-001 Revision: F, 2019* *8. NPTEL course on Robotics by Prof. Dilip kumar, IIT-Kharagpur*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1.Mr. Sreejith Balakrishnan, COMAU Robotics	*1. Prof. Robert Richardson, University of Leeds, UK.*	*1. Mr. V. Manoj Kumar, SRMIST*
2.Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability	*2 Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	*2. Dr. S. Prabhu. SRMIST*
3.Mr. Anand Nagarajan, Airbus		

Course Code	21MEE370T	Course Name	MICROSYSTEMS DESIGN AND APPLICATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify and understand various microsystems and its working for varying applications*
CLR-2:	*explain the working principles of micro sensors*
CLR-3:	*discuss and evaluate the rudiments of Micro fabrication techniques*
CLR-4:	*identify various actuators and its associated mechanics*
CLR-5:	*analyze the materials used for microsystem designs*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and	Environment &	Ethics	Individual & Team	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify and associate various microsystems and its working for varying applications*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*conceptualize and acquire the working principles of micro sensors*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*discuss and analyse the rudiments of Micro fabrication techniques*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*identify various actuators and its mechanics*	-	-	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*analyze the materials used for microsystem designs*	-	-	*2*	-	*1*	-	-	-	-	-	-	-	*1*	-	-

Unit-1: Introduction of Microsystems	***9 Hour***
Overview of Microsystems, Evolution of micro fabrication, Microsystems microelectronics, Multidisciplinary nature of Microsystems, Design and manufacture, Applications of Microsystems in automotive, healthcare, aerospace and other industries. Working Principle of Microsystems: Biomedical and biosensors. Micro sensors: Acoustic, Chemical, Optical, Pressure, Thermal	
Unit-2: Micro Sensors	***9 Hour***
Micro Sensors, Actuators, Systems and Smart Materials: An Overview Silicon Capacitive Accelerometer, Piezo resistive Pressure sensor, Fibre-optic sensors, Conductometric Gas Sensor, Electrostatic Comb drive, Magnetic Microrelay, Portable blood analyzer, Piezo electric Inkjet Print head, Micromirror array for Video projection, Micro-PCR Systems, Smart materials and systems	
Unit-3: Microsystem Fabrication	***9 Hour***
Diffusion, Deposition: Oxidation, Evaporation, Sputtering, CVD, PVD, Sol-Gel, Lithography: fundamentals, photoresists, lithography processes, Types: Optical, Electron-beam, focused ion beam, X-ray, LIGA process Etching: bulk and surface micro-machining isotropic and anisotropic, wet and dry etching, reactive ion etching and deep reactive ion etching. testing- micro-assembly, reliability studies. Soft lithography and polymer processing, Thick-film processing - Low temperature co-fired ceramic processing, Smart material processing	
Unit-4: Micro Actuations	***9 Hour***
Micro actuation using thermal forces, shape memory alloys, Piezoelectric crystals and electrostatic forces. MEMS with micro actuators: Microgrippers, micromotors, microvalves and micropumps, micro accelerometers, microfluidics. CNT actuators. Introduction to Scaling: Scaling in Geometry, Scaling in Rigid body dynamics, Scaling in Electrostatic forces, scaling in electromagnetic forces and scaling in fluid mechanics	

Unit-5: Materials for Microsystems	***9 Hour***
Microsystem materials and properties: Substrates and wafers, Wafer preparation Active substrate materials, Silicon as substrate material, Silicon Compounds, Si-Piezoresistors, GaAs, Quartz, Piezoelectric Crystals, Polymers and packaging materials. Three level of Microsystem packaging, Die level packaging, Device level packaging, System level packaging. Interfaces in microsystem packaging. Essential packaging technologies: die preparation, Surface bonding, Wire bonding, Sealing, 3D packaging	

Learning Resources	*1. Senturia, Stephen D. Microsystem Design. Germany: Springer US, 2005.* *2. Tai-Ran Hsu, MEMS & Microsystems Design and Manufacture, McGraw Hill, 2002.* *3. V.K. Varadan, K.J. Vinoy, and S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, Wiley, 2006.* *4. Serope Kalpakjian, Steven Schmid, Manufacturing Engineering and Technology, Pearson Education, 2019*	*5. Mikell P. Groover, Fundamentals of Modern Manufacturing: Processes and Systems Wiley, 1996* *6. Fundamentals of Microfabrication (Second Edition), Marc J. Madou, CRC press Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL33487- 2724, 2002.* *7. K. J. Vinoy, G. K. Ananthasuresh, Rudra Pratap, S. B. Krupanidhi, Micro and Smart Devices and Systems Springer 2014* *8. Microsystem Design, Stephen D Senturia, Publisher: Springer US, 1st ed. 2004*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. S Rajkumar/ Rane Engine Valve Ltd	*1 Dr. S. Saravana Perumal, Asso. Prof, NITTR, Taramani.*	*1. Dr. R. Ambigai, SRM IST*
2. Mr. G.M. Kumaravel/ Brakes India Ltd	*2 Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in*	*2. Dr.M. Prakash, SRM IST*
3. Dr. N. Saravanan, Principal Engineer, Smart Implements & Machinery and Sustainability, Mahindra Research Valley	*3. Dr. N. Arunachalam, Associate Professor, IIT Madras*	

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

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