ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 25
Syllabi for School of Mechanical Engineering Programmes

Professional Core and Elective 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

School of Mechanical Engineering

Professional Core Course

Regulations 2021

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

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MAC501T	Course Name	COMPUTATIONAL METHODS	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	*Mathematics*	Data Book / Codes / Standards	*Statistical Tables*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the concept of one dimensional wave equations and diffusion equation*
CLR-2:	*construct Fourier series for periodic functions and transform technique to solve elliptic equation*
CLR-3:	*understand the concepts of Euler's equations*
CLR-4:	*identify numerical technique to solve algebraic transcendental equations, ODE and PDE*
CLR-5:	*infer the concepts of probability, correlation and regression*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain analytical solution of partial differential equation*	*3*	*3*	
CO-2:	*justify the solution of elliptic type PDE and periodic functions*	*3*	*3*	
CO-3:	*evaluate the solution of functional and vibrational problems*	*3*	*3*	
CO-4:	*adapt numerical solutions for algebraic, transcendental, ODE and PDE*	*3*	*3*	
CO-5:	*solve Statistical problems related to day to day life*	*3*	*3*	

Module-1 - Transform Techniques	***12 Hour***
Laplace transform - Fourier transform - One-dimensional wave equation using Laplace transform methods - Displacements in long string - Longitudinal vibration of an elastic bar - One -dimensional diffusion equation using Fourier transform methods – One-dimensional diffusion equation using Fourier sine transform methods – One-dimensional diffusion equation using Fourier cosine transform methods. .	
Module-2 - Fourier Series and Elliptic Equation	***12 Hour***
Fourier series representation of periodic functions - Fourier transform methods for Laplace equation.	
Module-3 - Calculus of Variations	***12 Hour***
Euler's Equations - Functional involving x, y, y' - Functional on higher order derivatives - Functional dependent on functions of independent variables - Rayleigh-Ritz method.	
Module-4 – Numerical Methods	***12 Hour***
Solution of algebraic and transcendental equations-Iteration method-Newton's method- solution to ODE- Runge Kutta method of 4th order- Milne's predictor corrector method. Solution to PDE- Solution to Laplace equation-Leibman's method- Solution to Poisson equation- Solution to Parabolic type PDE- Bender Schmidt method-Crank Nicholson method.	
Module-5 - Statistical Techniques	***12 Hour***
Random Variables –Discrete and continuous random variables-Mean, median, variance, Standard deviation, moments, skewness, kurtosis, correlation, regression, coherence, multiple and partial correlation.	

Learning Resources	1. *Sankara Rao, K., "Introduction to Partial Differential Equations", PHI, New Delhi, 3rd edition 2011.* 2. *B .V. Ramana, "Higher Engineering Mathematics", McGraw Hill Publication, 2017.* 3. *Elsgolts, L., "Differential Equations and Calculus of Variations", Mir Publishers, Moscow, 2013.*	4. *S. S. Sastry, Introductory Methods of Numerical Analysis, 5thEdition, PH1, 2012* 5. *S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 11th Edition, 2015.* 6. *S. Ross, A First Course in Probability, 8th Edition., Pearson Education India, 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. Madhan Shanmugasundaram, Infosys Technologies, madshan@gmail.com*	1. *Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in*	1. *Dr. V. Subburayan, SRMIST*
	2. *Prof. K.C. Sivakumar, IIT Madras, kcskumar@iitm.ac.in*	2. *Dr. P.Sambath. SRM IST*

ACADEMIC CURRICULA

Robotics

Professional Core Courses

Regulations 2021

INSTITUTE OF SCIENCE & TECHNOLOGY
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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	21MEC521J	Course Name	ROBOTICS ENGINEERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*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 and end effectors*
CLR-2:	*analyse and understand transformation of end effectors position and being familiar with the kinematics and dynamics of robots*
CLR-3:	*understand the robot work cell layout and the recent trends in application of artificial intelligence and expert systems in robotics.*
CLR-4:	*acquire knowledge on emerging developments in robots*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*recognize the basics of robots and apply the concepts associated with end effectors*	*3*		
CO-2:	*acquire the knowledge about robotic control system, feedback devices and sensors*	*3*		
CO-3:	*evaluate transformation of end effectors position and being familiar with the kinematics and dynamics of robots*	*2*		
CO-4:	*analyse the robot work cell layout and application of artificial intelligence in robotics.*	*2*	*2*	

Module-1 - Introduction to Robotics and End Effectors	***6 Hour***
Introduction to Robotic, History - Developments in Robotics, Robot anatomy, Definition and law of robotics, Terminology of Robotics, Accuracy and repeatability, dexterity, compliance, RCC device of Robotics-Simple problems. Specifications of Robot-Speed of Robot- Robot joints and links, Robot Drive systems-Hydraulic, Pneumatic and Electric system. End Effectors - Mechanical grippers-Slider crank mechanism, cam type, Screw type, Rotary actuators, Magnetic grippers, Vacuum grippers, Gripper force analysis, Gripper selection and design considerations	
Module-2 - Robot Controls and Sensors	***9 Hour***
Control system for robot joint- Controllers, Control system analysis – Transient Response, Steady state, Trajectory planning of end effectors. Feedback devices-Encoder, Resolver, LVDT-Motion Interpolations, Adaptive control Sensors in robot, Characteristics of sensing devices, Selections and need of sensors, Touch sensors-Tactile sensor, Proximity and range sensors, Force sensor-Light sensors, Pressure sensors, Robotic vision sensor	
Module-3 - Robot Transformations, Kinematics and Dynamics	***9 Hour***
Robot kinematics-Types- 2D, 3D Transformation, inverse kinematics, Scaling, Rotation, Translation, Homogeneous Transformations, multiple transformations. Kinematic equations using Homogeneous Transformations - Joints, frame assignment to links, Orientation, direct kinematics Solving Kinematic equations – Velocities and Static forces in manipulators:- Jacobians, singularities, static forces, Jacobian in force domain, Dynamics:- Introduction to Dynamics.	
Module-4 - Robot Cell Design and Artificial Intelligence Applications	***6 Hour***
Robot work cell design - control-Sequence control Operator interface, Safety monitoring devices in Robot Mobile robot working principle, actuation using MATLAB, NXT Software Introduction to Artificial Intelligence, Need and application of AI.AI techniques, Artificial neural networks in manufacturing automation, Fuzzy decision and control, robots and application of robots using AI and FUZZY	

Laboratory Practice:			*30 Hour*
1.	*Introduction to programming using Arduino ide, Programming inputs and outputs*	*6.*	*Bidirectional speed control of DC motor through L293D or ULN2003 interface*
2.	*Interfacing Arduino with LED to Blink and fade*	*7.*	*Interfacing analog output -Servo Motor with Arduino*
3.	*Interfacing Arduino with Buzzer*	*8.*	*Angular positioning of servo motor by using the ultrasonic sensor with Arduino*
4.	*Interfacing digital read - proximity sensor and serial monitor with Arduino*	*9.*	*Controlling servo motor by using the Potentiometer with Arduino*
5.	*Interfacing digital input - ultrasonic sensor with Arduino for measuring distance*	10.	*Interfacing Bluetooth Module and IR Sensor with Arduino*

Learning Resources

1. *Deb. S.R, "Robotics Technology and flexible automation", Tata McGraw-Hill Education, 2009.*
2. *Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, "Technology Programming and Applications", McGraw Hill, 2012*
3. *Richard D. Klafter, Thomas. A, Chri Elewski, Michael Negin, "Robotics Engineering an Integrated Approach", Phi Learning., 2009*
4. *Francis N. Nagy, Andras Siegler, "Engineering Foundation of Robotics", Prentice Hall Inc., 1987*
5. *Sindo Kou, Welding Metallurgy, 2nd edition, John Wiley & Sons, Inc., publication, 2003.*
6. *John C. Lippold, Welding Metallurgy and Weldability, John Wiley & Sons, Inc., publication, 2015*
7. *Janaki Raman .P.A, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing company Ltd., 1995.Press, 2002*
8. *Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University Press, 2008*
9. *Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book co, 1987.*
10. *Craig. J. J. "Introduction to Robotics Mechanics and Control", Addison-Wesley, 1999*
11. *Ray Asfahl. C., "Robots and Manufacturing Automation", John Wiley & Sons Inc.,1985.*
12. *Bharat Bhushan., "Springer Handbook of Nanotechnology", Springer, 2004*
13. *. https://nptel.ac.in/courses/112101098*
14. *Russell Stuart, Norvig Peter, "Artificial Intelligence Modern Approach", Pearson Education series in AI, 3rd Edition, 2010.*
15. *Dan.W. Patterson, "Introduction to Artificial Intelligence and Expert Systems", PHI Learning, 2009.*
16. *Julian W. Gardner., "Micro sensor MEMS and Smart Devices", 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*	20%	-	-	10%-	20%	-
Level 2	*Understand*	20%	-	-	10%-	20%	-
Level 3	*Apply*	30%	-	-	40%-	30%	-
Level 4	*Analyze*	30%	-	-	40%-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr.S.Prabhu Shankar, DXC Technologies, Chennai	*Dr.S. Saravana Perumal, Associate Professor, NITTTR, Chennai*	*1. Dr. R.Ambigai, SRMIST*
		2. .Mr.V.Manoj Kumar,SRM IST

Course Code	21MEC522J	Course Name	APPLIED STATISTICAL MACHINE LEARNING	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:	*understand the broad introduction of statistical Machine learning*
CLR-2:	*be familiar with the concepts of Parametric Methods of Machine learning*
CLR-3:	*be familiar with the concepts of Non-Parametric Methods of Machine learning*
CLR-4:	*attain the knowledge of Machine learning Clustering Techniques*
CLR-5:	*understand different types of neural network algorithm*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*appreciate the statistical Machine Learning approach and problem solving principles*	*3*	*3*	*3*
CO-2:	*analyze the Parametric Methods of Machine learning Techniques*	*3*	*3*	*2*
CO-3:	*implement Non Parametric Methods of Machine learning Techniques*	*3*	*2*	*2*
CO-4:	*investigate the different Clustering Techniques*	*2*	*2*	*2*
CO-5:	*implement various Neural networks algorithm for solving case studies*	*3*	*3*	*3*

Module-1 - Statistical Machine Learning	***9 Hour***
Introduction to Statistical Machine Learning-Performance metrics-Accuracy, Precision, Recall, F1 score, Confusion matrix, ROC curves, Simple problem-Bias and Variance-Overfitting and Under fitting with examples, Cost function- Occum's Razor.	
Module-2 - Parametric Methods of Machine Learning Techniques	***9 Hour***
Regression analysis- Linear regression using Least square method-Single and Multiple types, simple problems- Polynomial Regression analysis, Simple problems- L1 and L2 Regularization- Classification algorithm- Logistic Regression using Maximum likelihood estimation- Gaussian Naive Bayes Theorem, Laplace estimator.	
Module-3 - Non-Parametric Methods of Machine Learning Techniques	***9 Hour***
k-Nearest neighbors algorithm (KNN) problems, Decision tree algorithm, Entropy, case studies -Random forest Algorithm, Grid search method-Support Vector Machine, Kernel Types- Apriori Algorithm problems-Reinforcement learning.	
Module-4 - Machine Learning Clustering Techniques	***9 Hour***
Data preprocessing- K Fold Cross Validation- Clustering techniques- K-means clustering problems- Dimensionality reduction technique-Principal component analysis (PCA), Fisher Linear Discriminant analysis (LDA), Singular value decomposition and Biplots-Simple problems.	
Module-5 – Neural Networks Algorithm	***9 Hour***
Introduction -Activation functions, Types, Perceptron with applications- Feed Forward Neural Network Algorithm, Recurrent Neural Network Algorithm, Back propagation Neural Network, Convolution padding and stride, Convolutional Neural Network(CNN), Simple problems-Gradient Descent For Neural Network.	

Laboratory Practice:	30 Hour
Machine Learning Lab Exercises: (Use Suitable Language and IDEs tools with ML application platform) 1. *Programing on Single and Multiple Variable Linear Regression analysis* 2. *Programing on Polynomial Regression analysis with case studies* 3. *Programing on Linear Regression using Gradient Descent Algorithm* 4. *Programing on Logistic Regression Algorithm with case studies* 5. *Programing on K Means Clustering Algorithm*	6. *Programing on k-Nearest Neighbours (KNN) Algorithm* 7. *Programing on Naive Bayes Classifier Algorithm* 8. *Programing on Decision Tree Algorithm* 9. *Programing on Random Forest Decision Tree Algorithm* 10. *Programing on Support Vector Machine kernel types Algorithm* 11. *Programing on Neural Network Algorithm*

Learning Resources	1. *Russell, Stuart, and Peter Norvig. Artificial Intelligence: A Modern Approach. 3rd ed. Prentice Hall, 2009. ISBN: 9780136042594.* 2. *Gelman, Andrew, et al. Bayesian Data Analysis. 2nd ed. Chapman and Hall/CRC, 2003. ISBN: 9781584883883.* 3. *Cristianini, Nello, and John Shawe-Taylor. An Introduction to Support Vector Machines and Other Kernel-based Learning Methods. Cambridge University Press, 2000. ISBN: 9780521780193* 4. *Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012* 5. *Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005*	6. *Hastie, Trevor, Robert Tibshirani, and Jerome Friedman. The Elements of Statistical Learning: Data Mining, Inference, and Prediction. 2nd ed. Springer, 2009. ISBN: 9780387848570* 7. *Pratap Dangeti, Statistics for Machine Learning, Packt Publishing,UK, 2017, ISBN 978-1-78829-575-8.* 8. *Ethem Alpaydin, Introduction to Machine Learning, Second Edition http://mitpress.mit.edu/catalog/item/default.asp?ttype=2&tid=12012* 9. *Simon O. Haykin, Neural Networks and Learning Machines, Pearson Education, 2016* 10. *Tom Mitchell, Machine Learning, http://www.cs.cmu.edu/~tom/mlbook.html*

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.S.Prabhu Shankar, DXC Technologies, Chennai	1. Dr. N.Arunachalam, Associate Professor, IIT Madras	1. Prof.S.Prabhu, SRMIST
	2. Prof. P.Hariharan, Professor, Anna University, CEG campus, Chennai	2.Mr.V.Manojkumar, SRMIST

Course Code	21MEC523J	Course Name	EMBEDDED SYSTEMS AND INTERFACING FOR ROBOT	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:	*create insights to the fundamental concepts of Embedded System*
CLR-2:	*learn to program the ARM microcontroller using assembly language*
CLR-3:	*be familiar with interface the microcontroller with the external world using a high-level language*
CLR-4:	*study about the Real time operating system and its programming*
CLR-5:	*identify the applications of embedded system in Robotics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*demonstrate fundamentals of embedded system design*	*1*	*-*	*2*
CO-2:	*implement different Robot languages with case studies*	*2*	*-*	*2*
CO-3:	*evaluate various Input output Communication module*	*2*	*-*	*3*
CO-4:	*analyze the RTOS concept with case studies*	*2*	*-*	*3*
CO-5:	*construct the hands-on experience on embedded system for robotics*	*1*	*1*	*3*

Module-1 -Embedded System-Introduction	***9 Hour***
Embedded system design process- embedded standards – block diagrams – powering the hardware - ISA architecture models - RISC versus CISC - RISC properties - RISC evaluation - compilation process – libraries – porting kernels – C extensions for embedded systems –emulation and debugging techniques.	
Module-2 - High Performance RISC Architecture	***9 Hour***
ARM: Architecture, organization and implementation - The ARM instruction set -The thumb instruction set - Basic ARM Assembly language program - ARM CPU cores.	
Module-3 – Real Time Communications	***9 Hour***
Real time communication –power and energy awareness – event triggered – rate constrained – time triggered - Keyboard scanning algorithm - LCD module display Configuration - Time-of-day clock - Timer manager - Interrupts - Interrupt service routines - Interrupt-driven pulse width modulation.	
Module-4 - RToS	***9 Hour***
Operating systems and its internals - Multitasking and Real time Operating Systems – Task Swapping Methods – Scheduler Algorithms – Priority Inversion – Task, Thread and Process – Choosing Operating System – Commercial Operating Systems – Linux.	
Module-5– Embedded Robot Applications	***9 Hour***
Introduction to TinyOS Programming and fundamentals of Programming sensors using nesC- Algorithms for WSN –Techniques for Protocol Programming. Case study on Home security system using embedded system, Soccer playing robot using embedded system.	

Laboratory Practice:	**30 Hour**
Robotics Lab Exercises: 1. Programming Exercise on Numbering system, Logic Gates 2. Embedded C program to interface LEDs, Switches and Counter. 3. Embedded C program to interface DC Motors, Stepper Motor, and Servo Motor rotate clockwise, anticlockwise and in angle (45°, 90°, 180°). 4. Embedded C program to generate an Interrupt process. 5. Embedded C program to build I2C communication between two microcontrollers.	6. Embedded C program to connect ESP32/ESP8266 to create a Webserver. 7. Demonstrate GPIO pin 21 to toggle every 2ms as an RTOS application 8. Write a pseudo-code that simulates a simple round-robin scheduler in an RTOS. 9. Write a program using RTOS that demonstrates multitasking. 10. Develop a basic temperature monitoring application using TinyOS

Learning Resources	1. Yifeng Zhu, "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C", E-Man Press LLC, 2023. 2. Elecia White, "Making Embedded Systems: Design Patterns for Great Software", O'Reilly Media, 2023. 3. Andrew N. Sloss, Dominic Symes, Chris Wright, "Arm System Developer's Guide: Designing and Optimizing System Software", Morgan Kaufmann, 2004	4. Jason .D. Bakos , "Embedded Systems: ARM Programming and Optimization",2015 5. Hermann Kopetz, "Real–Time systems – Design Principles for distributed Embedded Applications", Second Edition, Springer 2011. 6. P.Jayachandar, P.Brindha, M.Parimala Devi,"Advanced Microprocessors and Microcontrollers",2019

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. M.Vikram, Automotive Electronics Head ,Bosch	1. Dr. N.Arunachalam, Associate Professor, IIT Madras	1. Mr.V.Manojkumar, SRMIST
2.Mr. Anand Nagarajan / Airbus	2. Dr. Noor Mahammad SK, Assistant Professor, IIITDM,Kancheepuram	2.Prof.S. Prabhu, SRMIST

Course Code	21MEC524J	Course Name	KINEMATICS, DYNAMICS, AND CONTROL SYSTEM FOR ROBOT	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:	*understand and apply displacement and velocity kinematics to different robotic manipulators*			
CLR-2:	*understand and apply Lagrangian dynamics to different robotic manipulators*			
CLR-3:	*understand the concepts of task space, dynamic constraints and inverse dynamics*			
CLR-4:	*design control strategies for motion control of single joints*			
CLR-5:	*design control strategies for motion control of multiple joints and Force control*			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*determine direct and inverse kinematics of robotic manipulators*	2	1	2
CO-2:	*evaluate the manipulator dynamics using Lagrangian Equations of motion*	3	1	1
CO-3:	*analyze the task space and joint space dynamics*	3	1	2
CO-4:	*design control strategy for independent joints*	2	1	3
CO-5:	*design control strategy for multiple joint and force control*	2	2	2

Module-1 - Kinematics of Robot	***9 Hour***
Introduction: Spatial descriptions and transformations, Denavit-Hartenberg Notation, Forward and Inverse Kinematics of Robotic Manipulators: Stanford, SCARA and PUMA manipulators, Velocity Kinematics: Manipulator Jacobian.	
Module-2 - Dynamics of Robot - I	***9 Hour***
Lagrangian Dynamics: Kinetic and Potential Energy Expressions, Classical Formulation, Equations of Motion, Common Configurations, Manipulator Dynamics	
Module-3 - Dynamics of Robot - II	***9 Hour***
Newton-Euler Dynamics, Task space Dynamics, Constraints for manipulator, Joint and link flexibility, Inverse Dynamics for manipulators	
Module-4 - Independent Joint Control	***9 Hour***
Control Systems: Introduction to feed forward, feedback control and State-Space theory for linear systems, Independent joint control: SISO system, P and PI control, Actuator dynamics, set point tracking: PD and PID compensation, Trajectory interpolation, Feed forward control and computed torque	
Module-5 – Motion and Force Control	***9 Hour***
Multi variable control, Motion control of multi joint robot: Task-space motion control, Impedance control, Hybrid Position/ Force control, Robot Manipulation	

Laboratory Practice:	30 Hour
Lab 1: Direct Kinematics of a planar manipulator Lab 2: Inverse kinematics of a planar manipulator Lab 3: Manipulator Jacobian for a planar manipulator Lab 4: Dynamics of a two link manipulator using Lagrangian Equations Lab 5: Inverse dynamics of a two link manipulator Lab 6: Dynamics of a three link manipulator using Newton Euler algorithm	Lab 7: Feed Forward Servo control Lab 8: Torque control Lab 9: Controller for 1 DoF spring-mass-damper system Lab 10: Simulation of 2 DoF robot controller

Learning Resources	1. John. J. Craig, Introduction to Robotics: Mechanics and control, Fourth Edition, Pearson Publishers, 2017. 2. Spong and Vidyasagar, Robot Dynamics and Control – Wiley Publications, 2008. 3. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2003. 4. K.M. Lynch and F. C. Park, Modern Robotics: Mechanics, Planning and Control, Cambridge University Press, 2017. 5. Mittal R.K. and Nagrath I. J., Robotics and Controls, Tata McGraw Hill Publications, 2003.	6. K. Ogata, Modern Control Engineering, Pearson Education Asia, 4th Edition, 2002. 7. Benjamin C. Kuo, Automatic Control Systems, John Wiley and Sons, 9th Edition, 2010. 8. B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo, Robotics: Modelling, Planning and Control, Springer Publications, 2009. 9. M. T. Mason, Mechanics of Robotic Manipulation (Intelligent Robotics and Autonomous Agents), Bradford Books Publications, 2001. 10. K. S. Fu, R. C. Gonzalez, C. S. G. Lee, Robotics: Control, Sensing, Vision and Intelligence, McGrawHill Education, 2017.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
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Level 2	Understand	20%	-	-	10%-	20%	-
Level 3	Apply	30%	-	-	40%-	30%	-
Level 4	Analyze	30%	-	-	40%-	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	1. Prof. Babar Ahmad, NIT SRINAGAR	1. Dr. C. Shravankumar, SRMIST

Course Code	21MEC525J	Course Name	ROBOT PROGRAMMING AND SIMULATION	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:	*study about the Introduction of robot programming*
CLR-2:	*learn Robot programming languages and its applications*
CLR-3:	*be familiar with RAPID programming language with applications*
CLR-4:	*study about the Introduction of Robot Simulation*
CLR-5:	*acquire knowledge on virtual robotic simulation software*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the fundamental concepts of Robot programming*	2	-	3
CO-2:	*learn different Robot languages with case studies*	2	-	3
CO-3:	*demonstrate RAPID Programming with applications*	2	-	3
CO-4:	*analyze the Robot simulation concept with case studies*	1	2	3
CO-5:	*construct the hands-on Simulation of Industrial robot*	1	1	3

Module-1 - Robot Programming-Introduction	***9 Hour***
Flex pendent- Bendix Wrist Mechanism-Coordinate system of Robot-Jogging-Types, Interpolation-Interlock commands, Types and applications, case studies- Operating mode of robot- Off-line programming, Singularity error, Motion supervision	
Module-2 - Robot programming Languages	***9 Hour***
Robot programming Languages-Classifications, Structures, elements and functions- VAL-II programming with welding applications-Robot work cell design-Robot Interference with case studies- Robot cycle time analysis- Move master command language with applications	
Module-3 - RAPID Programming	***9 Hour***
Motion Instructions- Safety for robot cell -Task level programming-Evolution of Robot programming methods, Level of control-Path definition-Virtual Robot controller function- Subroutine, interrupts- Applications of Rapid programming.	
Module-4 - Robot Simulation	***9 Hour***
Introduction to Robot Simulation: Importance and advantages-Types of Simulation Motion-Velocity and acceleration motion analysis for robots- Robot path planning Optimization, Simulation Environments: ROS (Robot Operating System), Advanced ROS concepts and applications- Introduction to V-REP programming simulation.	
Module-5 – Simulation for Industrial Robots	***9 Hour***
Overview of simulation in different robotic field- Hands-on Simulation: Building and simulating robot painting models-Digital Twin Technology- Robot Studio® Suite 2022 for Virtual Robotics- Simulation tools Introduction-Gazebo, Robot DK, OCTOBUZ and Delfoi, Operating Procedures and Applications.	

Laboratory Practice:	***30 Hour***
Robotics Lab Exercises: *1. Programming IRB1410 robot for pick and placing operation both in manual and automatic mode.* *2. Programming IRB1410 robot to handle input and output modules using subroutines.* *3. Programming RV-8CRL Mitsubishi PLC based Industrial Robot for pick and place operation.* *4. V-REP-based navigation of mobile robot for path planning optimization.* *5. Analysis and Simulation using Robot studio software and real time Programming of IRB1410 robot* *6. Implementation of trajectory planning for Linear, Zig-zag and circular motion using Robot studio software for painting application.*	*7. IRB 360 Vision-Based Robot for Automated Object Quality Classification using Pick master software.* *8. Performance analysis of Accuracy and Repeatability of IRB1410 Industrial Robot using Taguchi analysis with Machine learning approach* *9. Robot studio software based path planning of Linear, Zig-zag and circulation motion for cycle time analysis.* *10. Writing a Symbol/Drawing using a pen on a paper using Robot studio software. 11. Robot Vibration measurement of soft gripper using lab view software*

Learning Resources	*1. Introduction to Robotics: Mechanics and Control" by John J. Craig* *2. "Robot Modeling and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar* *3. Deb. S. R. "Robotics Technology and Flexible Automation", Tata McGraw Hill publishing company limited, 1994* *4. Mikell. P. Groover, "Industrial Robotics Technology", Programming and Applications, McGraw Hill Co, 1995.* *5. Klafter. R.D, Chmielewski.T.A and Noggin's, "Robot Engineering: An Integrated Approach", Prentice Hall of India Pvt. Ltd.,1994.*	*6. Robotics Lab manual, 2007,SRMIST.* *7. Quigley .M, Gerkey .B & William .D, "Programming Robots with ROS: A Practical Introduction to the Robot Operating", O'Reilly Media, Inc., 2015.* *8. Joseph .L, "ROS Robotics Projects", Packt Publishing, 2021.* *9. ABB Robotics, "Operating manual Robot studio 5.14" Document ID: 3HAC032104-001 Revision: F, 2019.*

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.S.Prabhu Shankar, DXC Technologies, Chennai	*1. Dr. N.Arunachalam, Associate Professor, IIT Madras*	*1. Prof.S.Prabhu, SRMIST*
	2. Prof. P.Hariharan, Professor, Anna University, Chennai	*2.Mr.V.Manojkumar, SRMIST*

ACADEMIC CURRICULA

Computer Aided Design & Robotics

Common Professional Elective Course

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	21MEE602J	Course Name	ADDITIVE MANUFACTURING TECHNOLOGY	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:	*understand the need of design for AM*
CLR-2:	*understand additive manufacturing systems and its process*
CLR-3:	*understand need of post processing for AM*
CLR-4:	*understand rapid tooling and its applications*
CLR-5:	*understand future development of Additive Manufacturing*

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	*design for additive manufacturing processes*	*2*		
CO-2:	*identify the working principles and process parameters of additive manufacturing*	*3*		
CO-3:	*apply suitable post processing operation based on product and materials*	*2*		*1*
CO-4:	*apply the suitable tooling methods for any given industrial application*	*1*		*2*
CO-5:	*realize the future development of additive manufacturing*	*2*		*3*

Module	Hours
Module-1 – Design for Additive Manufacturing (DFAM)	***15 Hour***
Introduction to geometric modelling, Modelling of Synthetic curves like Hermite, Bezier and B-spline, Parametric Representation of freeform surfaces, Need for Design for Additive Manufacturing (DFAM), CAD tools, General Guidelines for DFAM, The Economics of Additive Manufacturing, Design to Minimize Print Time, Design to Minimize Post-processing. Multi scale design for Additive manufacturing, Mass customization, Biomimetic design, Design of multi-materials and functionally graded materials. *Practical: Design of complex geometry and multi-scale model using modelling software*	
Module-2 – Additive Manufacturing Processes	***10 Hour***
Liquid based process: Selective Laser Apparatus (SLA)- Solid Ground Curing (SGC) – Principles, process, materials, and applications - Extrusion-Based Processes: Fused Deposition Modelling (FDM) - Bio-Extrusion- Principles, process, materials, and applications- Sheet Lamination Processes: Laminated Object Manufacturing (LOM) - Bonding Mechanisms, process, Materials, applications. Powder Bed Fusion Processes: Selective laser Sintering (SLS)- Selective laser metal (SLM) - Electron Beam melting (EBM) Powder fusion mechanism and powder handling- process material and Applications - Directed Energy Deposition Processes- Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD) Processing-structure properties, relationships, materials, and applications.	
Module-3 – Post Processing of Additive Manufacturing Parts	***10 Hour***
Removal of 3D – printed parts from bed- Support Removal - improvement of Surface Texture – Accuracy- Aesthetic- Preparation for use as a Pattern-Property Enhancements using Non-thermal and Thermal Techniques- case studies. Guidelines for Selection of process – method for parts and Challenges. Post processing tools and devices.	
Module-4 – Rapid Tooling and Applications	***10 Hour***

Conventional Tooling, Rapid Tooling, Differences between Conventional and Rapid Tooling, Classification of Rapid Tooling: Direct and Indirect Tooling methods- Soft and Hard Tooling methods – case study with Rapid Tooling applications for investment Casting - silicon rubber mould – epoxy tools- Sand-Casting - Automotive Industry and jewellery industry components *Practical: Case study – Hard tooling-soft tooling application of automobile and aerospace components*
Module-5 –Future development in Additive Manufacturing ***15 Hour***
Computed Tomography (CT), Basic Components of CT, Different Types of CT Scanners, Magnetic Resonance Imaging (MRI), Ultrasound imaging, 3-D laser scanners, Industrial CT Scanners, 3D reconstruction and Reverse Engineering (RE), Image Reconstruction Procedure - Additive Manufacturing Related Technology in Sports, Rehabilitation, Device for Elderly, Forensic Science and Anthropology, Tissue Engineering and Organ Printing. *Practical: case study - 3D reconstruction of prosthetics using Reverse engineering tools*

Learning Resources	1. *Chua. C.K, "Rapid Prototyping", Wiley, 1997.* 2. *Hilton. P.D. et all, "Rapid Tooling", Marcel, Dekker 2000.* 3. *Jacohs P.F., "Stereolithography and other Rapid Prototyping and Manufacturing Technologies", ASME, 1996.* 4. *Pham D.T. and Dimov S.S., "Rapid Manufacturing; the technologies and application of RPT and Rapid tooling", Springer, London 2001.*	5. *Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.* 6. *Bio-Printing: Principles and Applications, Chua Chee Kai and Yeong Wai Yee, World Scientific Publishing, 2015.* 7. *Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGraw Hill, 2021.*

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%	-
Level 2	Understand	20%	-	-	20%	20%	-
Level 3	Apply	30%	-	-	20%	30%	-
Level 4	Analyze	30%	-	-	30%	30%	-
Level 5	Evaluate	-	-		30%	-	-
Level 6	Create	-	-		-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Parameswaran, Nokia, Chennai	*Dr. Raju Abraham, NIOT, Chennai.*	1. *Dr. S. Karuppudaiyan, SRMIST*
		2. *Dr. D. Raja, SRMIST*

ACADEMIC CURRICULA

Robotics

Professional Elective 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	21MEE521J	Course Name	ROBOT VISION	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 fundamental knowledge on sensors and Image acquisition system*
CLR-2:	*practice with the basics of image processing in spatial domain*
CLR-3:	*practice with the object recognition*
CLR-4:	*classify the images using deep learning in vision systems*
CLR-5:	*explore 3D vision with path planning*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*execute the image acquisition and compute the fundamentals of image processing*	3	1	2
CO-2:	*experiment with basic image processing techniques like smoothing, filtering, and thresholding*	3	1	2
CO-3:	*explore the object recognition and feature extraction algorithms*	1	3	2
CO-4:	*employ deep learning in vision and recognize the objects using the collision front algorithm.*	1	3	2
CO-5:	*demonstrate robot 3D Vision applications in navigation, depalletizing*	1	2	3

Module-1 - Image Acquisition and Fundamentals of Image Processing	***5 Hour***
Elements of visual perception, structure of eye, Image formation in eye-Image acquisition, Illumination and its types- Point sensor, line sensor, planar sensor, CCD , CMOS Cameras, stereo imaging-AI cameras - Digital images interfaces- -Spatial and Intensity Resolution	
Module-2 - Elements of Image Processing Techniques	***5 Hour***
Discretization, Neighbours of a pixel, connectivity, Distance measures, preprocessing Neighbourhood averaging, Median filtering. Image Enhancement, Histogram Equalization, Histogram Specification, Local Enhancement, Edge detection, Gradient and Laplace operators, Thresholding	
Module-3 - Object Recognition and Feature Extraction	***8 Hour***
Image segmentation, Edge linking, Boundary detection-Region growing, Region splitting and merging, Boundary Descriptors, Freeman chain code, Regional Descriptors, Recognition procedure, mahalanobic procedure	
Module-4 - Collison Fronts Algorithm and Deep Learning	***6 Hour***
Introduction, skeleton of objects. Gradients, propagation, Definitions, propagation algorithm, Thinning Algorithm, Skeleton lengths of Top most objects, Bayesian Learning, Decision Surfaces, Linear Classifiers, Deep learning for object classification	
Module-5 – 3D Vision and Robot Vision Applications	***6 Hour***
Methods for 3D vision 3D object recognition ,3D reconstruction, Automated Navigation guidance by vision system, vision based depalletizing, line tracking--Photogrammetry and Stereo, Automatic part Recognition.	
Laboratory Practice:	***30 Hour***

Practice on Image acquisition using Open Source Software 1. *Practice reading an image exercise on spatial resolution and sampling in Open Source Software* 2. *Practice on basics of image processing (Arithmetic, logical operations)* 3. *Practice on smoothing and filtering of images and inference on its parameter* 4. *Practice on histogram equalization and histogram specification*	5. *Practice on edge detection and thresholding* 6. *Practice on object recognition, counting of objects,* 7. *Practice on object recognition and representing its boundary,* 8. *Practice on object classification and recognition using deep learning,* 9. *Practice on 3D laser scanning and 10. Practice on 3D image constructions*

Learning Resources	1. *Fu .K.S, Gonzalez .R.S, Lee .C.S.G, "Robotics – Control Sensing, Vision and Intelligence", Tata McGraw-Hill Education, 2008.* 2. *Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, "Robotics Engineering an Integrated Approach, Phi Learning", 2009.* 3. *Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, "Industrial Robotics, Technology Programming and Applications", Tata McGraw-Hill Education, 2011.* 4. *Janaki Raman .P.A, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing company Ltd., 1995.* 5. *John J. Craig, "Introduction to Robotics Mechanics and Control", Third Edition, Pearson, 2008.* 6. *Rafel.C.Gonzalez and Richard E.Woods, "Digital Image Processing", Addison Wesley, New York, 2009.*	7. *Vernon, D., "Machine Vision - Automated Visual Inspection and Robot Vision", Prentice Hall International Ltd., New York, 1991.* 8. *William K. Pratt, "Digital Image Processing", John Wiley, New York, 2007.* 9. *Sid Ahmed M. A., "Image Processing Theory, Algorithms and Architectures", McGraw-Hill, New York,1995.* 10. *Umbaugh.S.E, "Computer Vision and image processing - Practical approach using CVIP tools, Prentice Hall of India, New Delhi, 1998.* 11. *Ramesh Jain, RangacharKasturi and Brain G. Schunk, "Machine Vision", McGraw Hill International Editions, Computer Science Series, Singapore, 1995.* 12. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1998 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 (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*10%-*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*10%-*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*40%-*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*40%-*	*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.A.Krishnan, IGCAR,kalpakkam*	1. *Dr.N.Arunachallam, IITM, chalam@iitm.ac.in*	1. *Dr. A.Vijaya, SRMIST,*
2. *Mr. Narasimhan Sridhar, TESA Engg, Chennai*	2. *Dr.A.Jothilingam, Visiting Faculty, MIT, Anna University. jothilingam@mitindia.edu*	2. *Dr. R. Senthilnathan , SRMIST*

Course Code	21MEE522J	Course Name	ADVANCED ROBOTIC SENSORS	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:	*recognize the need and basics of sensors, and smart sensors.*
CLR-2:	*analyze how different force, touch, displacement measurement, and position and feedback sensors are used in robotic applications.*
CLR-3:	*recognize various kinds of sensors and the significance of speech recognition.*
CLR-4:	*recognize the vision sensor modules, software structure, and integration of all together for specific applications*
CLR-5:	*integrate different sensors and learn how they function to comprehend different robotic applications.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*comprehend the fundamentals of the sensors used in robots and smart sensors.*	3	-	-
CO-2:	*identify the application of various position and feedback sensors, displacement measurement sensors, force, and touch sensors in robotic applications*	3	-	-
CO-3:	*analyse various miscellaneous sensors and voice recognition system*	3	-	-
CO-4:	*recognize the vision sensor modules, software structure and integration of all together for specific applications*	2	-	1
CO-5:	*integrate various sensors and their working to understand various robotic applications*	2	-	2

Module-1 - Fundamentals of Robotic Sensors and Smart Sensors	***6 Hour***
An Introduction to sensors and Transducers, History and definitions, Classification of various sensors, Smart Sensing, working of a smart sensor, networking of smart sensors, AI sensing, Need of sensors in Robotics, Case study on AI, Applications in robotics, Sensors in mobile and fixed robot configurations, Application of sensors in various robots, Case study on fixed robot configurations and mobile robot configurations, Sensor calibration and validation of sensory data .	
Module-2 - Position Sensors for Robots	***8 Hour***
Position sensors – Optical, non-Optical, Contact, non-contact type sensors position sensing, Range Sensing, types, and classification based on the Distance measurement technique. *Touch and Slip sensors, application in grippers as a feedback device, End effector feedback sensors, Sensors types of touch and slip sensors, Tactile sensors, Force sensors and their application in fixed robots. Torque Sensors and associated circuitry used for torque sensors, Velocity sensors, Accelerometer types, Proximity Sensor types, Lidar for mobile robot position tracking and localization.*	
Module-3 - Miscellaneous Sensors	***8 Hour***
Different sensing variables, Smell and smart e-nose sensors, Heat or Temperature Humidity classification of RTD and Thermocouples, Non-contact based temperature measurement, Pyrometry and Active, passive type of IR devices, Light sensors and application of light sensors in robotic interlocks, Speech recognition Systems and its types. Natural language processing system – an overview, Case study on voice recognition system, Need for telepresence and associated technologies, Telepresence and related technologies	
Module-4 - Vision Sensor Control	***6 Hour***
Introduction to vision sensor, working and principles of vision sensing – specific topics, classification of vision sensors, Integration of vision sensors to robot controller, Optics of vision sensor, End effector camera Sensor, Calibration of vision sensors, Robot Control through Vision sensors Robot vision locating position, Obstacle Avoidance, Robot guidance with vision system.	

Module-5 – Multi Sensor Controlled Robot Assembly	***6 Hour***
Material Handling using robot Grippers, Multi sensor base robot assembly, Classification of grippers and gripping methods based on operation Gripping methods, accuracy. Robot centered compliance for fixed robot, Compliance system for grippers. Case studies: Vision assisted Industrial robot, Vision assisted mobile robot, Robot to robot communication in multi robot assembly for industrial application.	

Laboratory Practice:	***30 Hour***
1. Integrating Smart sensors like temperature, humidity, light sensors with digital output 2. Integrate multiple sensors with microcontrollers for data acquisition & data processing. 3. Wireless transmission of sensor data to a remote device retrieving and performing data analysis. 4. Development of sensor node balancing in tinyOS platform 5. Development of smart sensors, stages node MCU 6. Sensor calibration, smart sensor -01to an IOT platform 7. Exercise on Range sensing and non-contact sensing devices	*8. Exercise on Gripper force sensing analysis and integration to grab an object 9. Implementing LIDAR and measurement of distance for an object 10. Voice base i/o control and voice base actuation sensory using android platform. 11. Interfacing vision sensor to virtual workbench for data acquisition, camera calibration. 12. Barcode scanning using camera - virtual work bench. 13. Integration of sensor -02 with IOT platform, end effector compliant sensor for gripping*

Learning Resources	*1. Richard D. Klafter, Thomas .A, ChriElewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009. 2. John Iovice, "Robots, Androids and Animatrons", McGraw Hill, 2003. 3. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics – Control Sensing, Vision and Intelligence", Tata McGraw-Hill Education, 2008. 4. Mikell P Groover& Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, Tata McGraw-Hill Education, 2012. 5. SabrieSoloman, Sensors and Control Systems in Manufacturing, McGraw-Hill Professional Publishing, 2nd Edition, 2009. 6. Julian W Gardner, Micro Sensor MEMS and Smart Devices, John Wiley & Sons, 2001..SarojKaushik, Logic and Prolog Programming, New Age International Ltd.*	*6. Ghosh, Control in Robotics and Automation: Sensor Based Integration,Allied Publisher. 7. Mikell P Groover& Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, "Industrial Robotics, Technology Programming and Applications", Tata McGrawLHill Education, 2011. 8. John J. Craig, "Introduction to Robotics Mechanics and Control", Third Edition, Pearson, 2008. 9. Rafel.C.Gonzalez and Richard E.Woods, "Digital Image Processing", Addison Wesley, New York, 2009.DrorSarid, "Scanning Probe Microscopy", Oxford University Press, Revised Edition, 1994. 10. Elwenspoek M. and Wiegerink R., "Mechanical Microsensors", Springer-Verlag Berlin, 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*	20%	-	-	10%-	20%	-
Level 2	*Understand*	20%	-	-	10%-	20%	-
Level 3	*Apply*	30%	-	-	40%-	30%	-
Level 4	*Analyze*	30%	-	-	40%-	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.S.Saravana Perumal, Associate Professor, NITTTR, Chennai*	1. *Dr.R.Ambigai, SRMIST*
		2. *Mr.V.Manoj Kumar, SRMIST*

Course Code	21MEE523T	Course Name	ADVANCED CONTROL SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explicit the mathematical models of control components and physical systems*
CLR-2:	*understand the concepts of time domain analysis*
CLR-3:	*detailed study of frequency response*
CLR-4:	*evaluate the stability of non-linear systems*
CLR-5:	*recognize the use of advanced control systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*determine the models of control components and physical systems*	3	-	-
CO-2:	*summarize the various concepts on time response analysis*	3	-	-
CO-3:	*investigate the stability of systems based on frequency domain by using different techniques*	3	-	2
CO-4:	*discuss the stability of Non-linear system*	2	-	2
CO-5:	*illustrate the concepts of Advanced control systems*	2	-	3

Module-1 Introduction to Control System	***9 Hour***
Introduction – Open loop and closed loop systems, , Feedback and Feed forward control systems, Examples - Transfer function and basis of Laplace transforms, Need for mathematical modeling, Tutorial - Modeling of physical systems – Representation of Mechanical Systems ,Translational and Rotational systems, Thermal, Hydraulic systems and Electrical Systems – Block diagram Algebra, Evaluation of transfer function using block diagram reduction - Signal flow graphs and evaluation of transfer function	
Module-2 - Time Response Analysis	***9Hour***
Continuous time signals, Standard Test signals, Classification of continuous time systems – Linear- Nonlinear – Time variant – Time invariant – Static – Dynamic, Time response of second order system - Time domain specifications - Types of systems - Steady state error constants -Generalized error series, Introduction to P, PI and PID modes of feedback control	
Module-3 - Frequency Response Analysis	***9 Hour***
Correlation between time and frequency response - Polar plots, Bode plots - Frequency domain specifications- Concept of stability – stability & location of the poles in S-plane - Characteristic equation, Routh-Hurwitz stability criterion, Root Locus concepts- Construction of root locus – Root contours, Absolute and Relative stability - Nyquist stability - Nyquist stability criterion - Assessment of relative stability – Gain and Phase Margin	
Module-4 - Non-Linear Control Systems	***9Hour***
Introduction - Non-Linear dynamics, Common Physical Nonlinearities - Basic concepts of phase plane Analysis, Phase Portraits, Singular Points, Symmetry in Phase plane portraits, Non-linear Systems, Equilibrium Points, Stability of nonlinear system, Lyapunov's Stability criterion, Construction of phase plane trajectories, Describing function of common Nonlinearities, stability analysis by describing function	

Module-5 – Advanced Control Systems	***9Hour***
Introduction - Adaptive control, model reference adaptive control (MRAC), Self-tuning control - Fuzzy logic control, case studies - Neural networks, model, controller, Learning control architecture , case studies - P,PI, PD and PID Controllers, Intelligent Controllers-Case Studies	

Learning Resources	1. *M.Gopal, Digital Control and State Variable Methods: Conventional and Intelligent Control System McGraw Hill 3 rdEdition, 2008* 2. *I.J.Nagrath, M.Gopal, Control System Engineering,5th edition,New age international (P) limited,2015* 3. *Richard C Dorf and Robert H Bishop, "Modern Control Systems", 13th edition, Pearson Education, 2016.* 4. *Norman S Nise, Control Systems Engineering, 7th edition, Wiley, 2015.*	5. *Roland S. Burns, Advanced Control Engineering, Butterworth-Heinemann, First edition, 2001* 6. *Deseneni, Subbaram Naidu, "Optimal Control Systems", 1st edition, CRC Press, 2003.* 7. *Jean-Jacques E Slotine, Weiping Li, Applied Nonlinear Control", Prentice Hall of India-New Jersey, 1991*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (50%)		Continuous Learning Assessment (CLA) Life-Long Learning CLA-2 (10%)		Summative Final Examination (40% weightage)	
		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. *Dr. S. Oliver Nesa Raj, SRMIST*
		2. *Dr. S.Prabhu, SRMIST*

Course Code	21MEE524T	Course Name	AI FOR 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 :	*familiarize the AI and its Method*
CLR-2 :	*understand various search algorithms*
CLR-3 :	*familiarize with adversarial search*
CLR-4 :	*understand the AI techniques*
CLR-5 :	*familiarize various applications of AI in Robotics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1 :	*demonstrate about different AI methods and its types*	*1*	*1*	*1*
CO-2 :	*apply various search algorithms techniques*	*2*	*2*	*2*
CO-3 :	*analyze adversarial search algorithms for real time scenarios*	*2*	*2*	*2*
CO-4 :	*acquired knowledge about AI techniques*	*1*	*3*	*2*
CO-5 :	*explorations of various applications of AI in Robotics*	*1*	*3*	*2*

Module -1: Introduction to AI and its Methods	***9 Hour***
Introduction of Artificial Intelligence and expert system. Well-defined problems and solutions-Case study on formulating problems - Toy Problems – Tic-tac-toe problems, Missionaries and Cannibals Problem, Real World Problem – Travelling Salesman Problem. AI Methods: Introduction: Machine learning- Deep learning- Natural language processing- Expert systems- Evolutionary algorithms- Reinforcement learning- Probabilistic graphical models- Transfer learning- Adversarial learning- Swarm intelligence	
Module -2: Search Algorithms	***9 Hour***
Search Strategies: Uninformed or Blinded Search, Breadth First Search, Uniform Cost Search, Depth First Search, Depth Limited Search, Iterative Deepening Depth First Search, Bi-directional Search, Comparing Uniformed Search Strategies - Informed Search Strategies: Heuristic Information, Best-First Search, Greedy best first search, Branch-and-Bound Search, Optimal Search and A and Iterative Deepening A*, Local search and optimization problems : Hill-climbing search, Local beam search- Simulated Annealing-Tabu search-Genetic Algorithms.*	
Module -3: Adversarial Search	***9 Hour***
Optimal decisions in games-The minimax algorithm-Optimal decisions in multiplayer games-Alpha-Beta Pruning-Move ordering-Imperfect Real-Time Decisions-Stochastic games-Partially Observable Games-State-Of-The-Art Game Programs, Alternative Approaches-Defining constraint satisfaction problems-Constraint propagation: inference in CSPs , Backtracking search for CSPs, Local search for CSPs	
Module -4: AI Techniques	***9 Hour***
Convolutional neural networks- Generative adversarial networks- Language modeling- Rule-based systems- Genetic algorithms- Q-learning- First-order logic- Bayesian networks- Pretrained models- Ant colony optimization- Support vector machines- Random Forest. Fundamentals on Generative artificial intelligence.	

Module -5: Applications of AI in Robotics	9 Hour
Biometrics Recognition: Face Recognition- Speaker Recognition. Customer Service -Assembly- Imaging - Machine Learning – Agriculture - Robot picking - Crop harvesting/wedding. Manufacturing-Damage control and quick maintenance - Automatic control. Nuclear waste management, Assembly line quality inspection, Healthcare, Transportation, Smart home appliances, Aerospace.	

Learning Resources	1. Russell (Stuart), 'Artificial Intelligence Modern Approach', Pearson Education series in AI, 3rd Edition, 2014. 2. Dan.W.Patterson, 'Introduction to Artificial Intelligence and Expert Systems', PHI Ltd, 2007. 3. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE)", Mc Graw Hill-2010 4. Deepak Khemani "Artificial Intelligence", Tata Mc Graw Hill Education 2013	5. Mahboob Elahi · Samuel Olaiya Afolaranmi· Jose Luis Martinez Lastra · Jose Antonio Perez Garcia, A comprehensive literature review of the applications of AI techniques through the lifecycle of industrial equipment, Discover Artificial Intelligence, (2023) 3:43 | https://doi.org/10.1007/s44163-023-00089-x 6. https://www.v7labs.com/blog/ai-in-robotics 7. Banh, L., Strobel, G. Generative artificial intelligence. Electron Markets 33, 63 (2023). https://doi.org/10.1007/s12525-023-00680-1

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. Lino John, Relationship Manager and Digital Program Manager TATA Consultancy Limited		1. Dr. M. R. Stalin John, SRMIST
2. Mr. Siva Neelakantan, Principal infrastructure, Architect GE Aerospace, USA		2. Mr. V. Manoj Kumar, SRMIST

Course Code	21MEE525J	Course Name	INTERNET OF ROBOTIC THINGS (RIoT)	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 taking this course is to:***
CLR-1:	*understand various types of sensors for stationary and mobile robots*
CLR-2:	*help identify network requirements to connect various IoT devices*
CLR-3:	*discuss various platforms available for computation*
CLR-4:	*understand various threats to security*
CLR-5:	*create awareness of current applications and potential for future applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify and select various sensor requirements for a robot*	*3*		
CO-2:	*analyse the requirements and choose apt connectivity*	*3*		*2*
CO-3:	*decide and choose the best application platforms*	*3*		
CO-4:	*design a secure connection for each IoT*	*1*	*3*	
CO-5:	*innovate current applications for other needs*	*3*		*2*

Unit-1: Introduction of IoT and Robotic Sensors — ***4 Hour***

Definition and Characteristics of IoT, Genesis of IoT, IoT and Digitization, IoT Impact, Convergence of IoT, IoT Challenges, Computer Vision and Pattern Recognition, Place categorisation and semantic mapping, Markov Chain and grid occupancy for representation of dynamic environment, RFID, LIDAR and 360° LIDAR systems for 3D representation.

Unit-2: Network Protocols — ***6 Hour***

Cellular Network: 3G, 4G, 5G, Low, Medium and Strong range communication (Nearfield, Wireless Hart mZ-Wave, Zigbee, Bluetooth module, RF communication, VSAT, PAN, WAN, BGAN, LoRaWAN, 6LoWPAN).

Unit-3: Internet Connectivity/ IoT Protocols — ***8 Hour***

Communication protocols - TCP, up, UDP, MQTT, CoAP, XMPP, DTLS, AMQP, LLAP, DDS, Routing Protocols - IPV4, IPV6, MIPv4 and MIPv6, Cognitive RPL (CORPL), Lossy Network, Channel Aware Routing Protocol (CARP), Dynamic Host Configuration Protocol (DHCP), Internet Control Message Protocol (ICMP).

Unit-4: RIoT Platforms and Security — ***8 Hour***

Robotic Platforms – Introduction, ROS, RT Middleware, RSNP, ORiN, CANOpen, UNR-PF; Cloud Platforms – Introduction, M2M, M2M2A – architecture.
Threats to privacy and security, Assessment of security concerns, Attacks on IoT devices, Rules and standards on privacy and security, mTLS, Types [Network, Embedded, Firmware], Impacts on privacy and society.

Unit-5: IoRT Applications: Present and Future — ***4 Hour***

Humanoid Robots, Mobile Robots, Flying Robots, Swarm Robots, Systems Maintenance, Manufacturing, Home Automation, Medical Assistance, Entertainment and Military.

Lab Practice:
Ex 1: Introduction to position and temperature Sensors,
Ex 2: CMOS Imaging Sensor Experiment,
Ex 5. MQTT protocol implementation,
Ex 6: Implement basic functionalities in ROS,
Ex 8: IoT Security Vulnerability Assessment,

Ex 3. RFID System Implementation, *Ex 4: Wireless Communication Protocol Comparison,*	*Ex 9: Mobile Robot Navigation Experiment,* *Ex 10: Home Automation System Prototype.*

Learning Resources	1. *David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Reprint)." IoT Fundamentals: Networking Technologies, Protocols and Use cases if the Internet of Things" First Edition, Pearson Education (Cisco Press Indian Reprint ISBN 978 9386873743).* 2. *Vijay Madisetti and Arshdeep Bagha, "Internet of Things- A Hands-On Approach" , First Edition, VPT, 2014 (ISBN: 978 8173719547).* 3. *Raj, pethuru, "The Internet of Things"* 4. *Y. Kanetkar, S. Korde; 21 Internet of Things (IOT) Experiments: Learn IoT, the programmer's way, first edition, BPB Publications, 2018.* 5. *Relevant research articles*	6. *M. Jan Holler, et al., From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence, first edition, Academic Press, 2014.* 7. *Raj Kamal, "Internet of Things – Architecture and Design Principles", First Edition, McGraw Hill Education, 2017. (ISBN: 978-9352605224* 8. *Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv4: The evolving world of M2M communications", ISBN:978-1-118-47347-4, Willy Publications* 9. *Bolton W., "Mechatronics", 4th Edition, Pearson publishers, 2010*

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%	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
	Dr. Christy Jackson J, VIT	*Dr. Deborah Serenade Stephen, SRMIST*

Course Code	21MEE526T	Course Name	SMART MOBILITY 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:	*device the 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:**	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*design and kinematic modeling of mobile robots and wheels*	*3*	*-*	*2*
CO-2:	*apply the control algorithms involved in mobile robots*	*3*	*1*	*1*
CO-3:	*familiar with sensors used for perception*	*3*	*-*	*1*
CO-4:	*explore algorithms in localizations*	*1*	*-*	*2*
CO-5:	*develop mobile robot and its control*	*1*	*1*	*3*

Module-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

Module-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, backstepping control

Module-3 - Perception ***9 Hour***

Sensors for mobile robots-Classification, performance, -Wheel sensor, Heading sensor -Accelerometer, Inertial measurement -Motion sensor, range sensors-Global positioning system (GPS), Doppler effect-based sensors-Vision sensor- LIDAR sensor-uncertainty in sensors

Module-4 - Localization and Mapping ***9 Hour***

Major challenges-localization based navigation-Belief representation, Map representation- Probabilistic Map, SLAM-Autonomous map building-Odometric position estimation-Markov localization, Bayesian localization, Kalman localization-Positioning beacon systems-Simulation- Tutorial on mobile robot localization and mapping

Module-5 – Planning and Navigation ***9 Hour***

Navigation system – Global, Local-Types- Direct, Relative and absolute, Planning and Reaction-Path Planning –static and dynamic environment-Graph search, D algorithm, Tutorial on D* algorithm, Potential field. Obstacle avoidance, Global Path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), Rapidly-exploring random tree (RRT), Tutorial on PRM, RRT, Bug algorithm, Histogram, Curvature velocity techniques-Simulation using open source 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. 6. George A. Bekey "Autonomous Robots" MIT Press. 7. 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	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. Visweswaran Jagadeesan, National instrument	1. Dr. Indra Narayan Kar, Professor, IIT Delhi	1. Dr. A. Vijaya, SRMIST
2 Dr. D. Dinakaran, HCL Technologies, ddinakaran.d@hcl.com	2. Dr. T. Deepan Barathi Kannan, CEG, Anna University	2. Mr. V. Manoj kumar. SRMIST

Course Code	21MEE527T	Course Name	HUMANOID ROBOT	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:	*study and understand the principle of Humanoid Robotics.*
CLR-2:	*apply the Kinematics and Dynamics concepts in Humanoid Robotics*
CLR-3:	*study with the various Programming and Control in Humanoid Robotics*
CLR-4:	*evaluate the Sensory Integration of various components in Humanoid Robotics*
CLR-5:	*familiarize yourself with ethical and Social Impact of Humanoid robot.*

Course Outcomes (CO):	At the end of this course, learners will be able to:	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the principle and philosophy of Humanoid Robotics.*	3	-	-
CO-2:	*apply the Kinematics and Dynamics concepts in Humanoid Robotics*	3	-	2
CO-3:	*impart knowledge in various concepts Programming and Control in Humanoid Robotics*	3	-	-
CO-4:	*apply the Sensory Integration of various components in Humanoid Robotics*	2	-	1
CO-5:	*understand various Ethical and Social Impact of Humanoid robot*	2	-	2

Module-1 - Introduction to Humanoid Robotics	***9 Hour***
Overview and history of humanoid robots - Fundamental principles of kinematics and dynamics of humanoid robots - Structural design materials of humanoid robots - Electrical Systems: Power supply, energy efficiency, and electrical safety of robot design, Walking and Locomotion -Types of sensors and their integration into robotic systems - NAO Robot (8 DOF)	
Module-2 - Kinematics and Dynamics	***14 Hour***
Spatial descriptions and transformations - Advanced Kinematics and Inverse manipulator kinematics in robot movement -Trajectory Planning for humanoid robot -Introduction to legged locomotion in humanoid robot - Stability and Balance in humanoid robot - Manipulator dynamics - Linear and Nonlinear Control of manipulators - GAIT Analysis	
Module-3 - Programming and Controller	***7 Hour***
Robot Programming Languages, Artificial Intelligence in Robotics, Machine Learning Applications, Natural Language programming (NLP), Behavioral Programming, Autonomous Navigation, Human-Robot Interaction (HRI), Security and Privacy, Walking methods like Zero Moment Point (ZMP) criterion and dynamically stable methods.	
Module-4 - Sensory Integration to Humanoid Robot	***6 Hour***
Vision Systems, Tactile Sensing, Auditory Systems, Sensor Fusion, Force control, Localization and Mapping using cameras, LIDAR, Motion Detection and Tracking, Incorporating sensory information, Human-Machine Interface (HMI), Facial and emotional sensing in humanoid robots	
Module-5 – Applications of Humanoid robot and Future Directions	***9 Hour***
Healthcare Robotics, Disaster Response, Education and Training, Space Exploration, Entertainment and Social Interaction, Ethical and Social Impact of humanoid robot, Future Trends of Humanoid robot	

Learning Resources	1. *J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison Wesley (2003).* 2. *Sebastian Thrun, Wolfram Burgard, and Dieter Fox "Probabilistic Robotics" The MIT Press (2005)*	3. *Dragomir N. Nenchev, Teppei Tsujita, "Humanoid Robots: Modeling & Control" , Butterworth-Heinemann Inc(2018)* 4. *Mittal RK, Nagrath IJ, Robotics and Controls, Tata McGraw Hill Publications, 2003.* **5.** *https://www.cs.umd.edu/~nkofinas/Projects/KofinasThesis.pdf*

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*	*40%*	-	*30%*	-	*40%*	-
Level 2	*Understand*		-		-		-
Level 3	*Apply*	*40%*	-	*40%*	-	*30%*	-
Level 4	*Analyze*		-		-		-
Level 5	*Evaluate*	*20%-*	-	*30%-*	-	*30%*	-
Level 6	*Create*		-		-		-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
	1. *Dr. Sagar Telrandhe, Manager, M/s slumberger India Limited, Pune*	1. *Dr. N.Harshavardhana, SRMIST*
	2. *Dr. M. Manjaiah, Department of Mechanical Engg. NIT Warangal*	*2, Dr.Sundar Singh Sivam, SRMIST*

Course Code	21MEE528T	Course Name	NANO 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:	*be familiar with the concepts of principles and functions related with the natural nanomachines.*
CLR-2:	*learn the characterization methodology and prototyping.*
CLR-3:	*understand the theory of assembly and nanomanipulation.*
CLR-4:	*understand the principles and techniques of miniaturization of actuators and case study.*
CLR-5:	*acquire the knowledge about biomolecules and characterizations.*

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	*understand the concept, applications, and types of various nanorobotic systems*	3	-	-
CO-2:	*learn the Characterization methodology of nanorobot and nanorobotic systems*	3	-	-
CO-3:	*identify the Assembly and micro/nano manipulation with Nanodevices*	3	-	-
CO-4:	*understand the Actuator Theory, Miniature robotic systems and some Case studies of various miniature robots and micro/nano systems.*	2	-	1
CO-5:	*recognize the inorganic biomolecules and molecular machines and their characterizations.*	2	-	2

Module-1 - Concepts and Methodology of Nanorobotics ***9 Hour***

Introduction To Robotics – Applications and Types of Nanorobotic Systems - Magnetic Nanorobots, MRI Guided Nanorobots, Nano Device Structures, Prototyping of Nanostructures Rotary Nanomotors, NEMS Based Linear Bearings, Characterization Methodology- Molecular Dynamics, Virtual Reality Techniques, Mechano Synthesis. Forces Involved- Vander Waals Forces, Capillary Forces, Contact Angle, Contact Energy, Surface Tension, Elastic Contact Mechanics, Electrical Double Layer, Hydrodynamic Forces

Module-2 - Assembly and Nanomanipulation ***9 Hour***

Introduction To Assembly and Manipulation, Nano/Micro Gripping Mechanisms, Position Sensors - Encoder, Resolver and LVDT. Microscopic Analysis- SEM And TEM – AFM Based Methods, Nanoscale Force Tracking, Nanomechanical Cantilever Based Manipulation, Surface Roughness and Topography, Semiconductor Nanodevices.

Module-3 - Miniaturization of Actuators and Case Study ***9 Hour***

Inorganic Molecular Machines- Rotaxane, Cafenanes, Synthetic Contractile Polymers, Bio nano Motors- Bacterial Guided Nanorobotics, ATP Synthase, Kinesin, Myosin Motors, Dyenin, Flagella Motors, Optical Tweezers- DNA Tweezers. Actuators and Passive Joints, Viral Protein Linear Motors, Protein Based Nanosprings, Alpha Helix Bundle Proteins, Beta Proteins, Ion Channels.

Module-4 - Biomolecules and Characterizations ***9 Hour***

Small Scale Robots, Scaling Laws -Dependent Phenomena, An overview of the current state of the Micro/Nano Robotics Field Fabrication Methods of Small-Scale Actuators, and Sensors.Power Sources - Micro/Nano Systems, Miniature Robotic Systems - Mobile Robots, Micro/Nano Manipulation Devices, Micro actuators: Ceramics, Shape memory alloy (SMA), Polymers, MEMS. Different Micro/Nano Scale Mechanisms, Design a Micro/Nano Scale Mechanism - Behavior With Scaling, Lithography. Case Studies of various miniature robots and Micro/Nano Systems.

Module-5 – Applications of Nano Robots in Medicine	9 Hour
Robots In Surgery, Robots in Blood Stream, Vasculitis for Molecular Transport, Biocompatibility Interaction Of Vasculoids, Mechanical Interaction of Vasculoids Cellulocks, Nanorobots For Drug Delivery, Chromallocytes, Lapping, Buffing, Honing, and Super Finishing.	

Learning Resources	1. Constantinos Mavroidis, Antoine Ferreira, "Nanorobotics: Current Approaches and Techniques", Springer Science & Business Media, 2013. 2. Norio Taniguchi, "Nanotechnology", Oxford University Press, Cambridge, 1996. 3. ParagDiwan and Ashish Bharadwaj, "Nanorobotics", Pentagon Press Publishers, New Delhi, 2006 4. Michael Gauthier and StephaneRegnier, "Robotic Microassembly", John Wiley and Sons, Inc. Publishers, IEEE, 2010 5. Nicolas Chaillet and StéphaneRégnier, "Microrobotics for Micromanipulation", John Wiley and Sons USA. 2010. 6. Mustapha Hamdi, Antoine Ferreira, "Design, Modeling and Characterization of Bio-Nanorobotic Systems". Springer Publications. 2011. 7. Mustapha Hamdi, Antoine Ferreira, "Design, Modeling and Characterization of Bio-Nanorobotic Systems". Springer Publications. 2011.	8. ConstantinosMavroidis and Antoine Ferreira, "Nanorobotics: The Vision and Applications", Springer Sciences, New York, 2013. 9. Mittal RK, Nagrath IJ, Robotics and Controls, Tata McGraw Hill Publications, 2003. 10. Paras N. Prasad, "Nanophotonics", John Wiley & Sons, (2016). 11. Bhushan .B, "Handbook of Micro/Nanotribology", CRC Press, 2nd Ed., 1999. 12. Morris V.J., Kirby R., Gunning P., "Atomic Force Microscopy for Biologists", London, Imperial College Press, 1999. 13. DrorSarid, "Scanning Probe Microscopy", Oxford University Press, Revised Edition, 1994. 14. Elwenspoek M. and Wiegerink R., "Mechanical Microsensors", Springer-Verlag Berlin, 2001.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (50%)		Continuous Learning Assessment (CLA) Life-Long Learning CLA-2 (10%)		Summative Final Examination (40% weightage)	
		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
.Mr.S.Prabhu Shankar, DXC Technologies, Chennai	Dr.S.Saravana Perumal, Associate Professor, NITTTR, Chennai	1. Dr.R.Ambigai, SRMIST
		2. Dr.S.Prabhu, SRMIST

Course Code	21MEE529J	Course Name	FUZZY LOGIC AND EXPERT SYSTEM	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:	*develop the fundamental concepts of Fuzzy logic analysis*
CLR-2:	*be familiar with Fuzzy Inference Systems for Robotics*
CLR-3:	*be familiar with the concepts of Fuzzification and Defuzzification*
CLR-4:	*be familiar with the concepts of Hybrid Algorithm*
CLR-5:	*lean about the introduction of Expert Systems*

Course Outcomes (CO):	**At the end of this course, learners will be able to:**	**Programme Outcomes (PO)**		
		1	2	3
CO-1:	*apply the fundamental concepts and application of Fuzzy logic analysis*	*1*	*1*	*1*
CO-2:	*demonstrate the Fuzzy rule based system*	*1*	*1*	*3*
CO-3:	*evaluate and analyze the fuzzification and defuzzification*	*1*	*1*	*3*
CO-4:	*analyze various hybrid learning fuzzy system*	*1*	*3*	*2*
CO-5:	*implement knowledge on different expert system for real time application*	*1*	*3*	*2*

Module-1 - Introduction to Fuzzy Logic	***6 Hour***
Overview of Fuzzy Logic- Basic concepts, Crisp and fuzzy sets, and membership functions- Fuzzy Logic in Robotics, Importance, advantages, and challenges- Applications of Fuzzy Logic in Robotics, Robot control, path planning, and decision-making, Fuzzy logic controller function	
Module-2 - Fuzzy Inference Systems for Robotics	***6 Hour***
Mamdani and Sugeno Fuzzy Models, Construction and applications- Fuzzy Rule-Based Systems, Design and implementation in robotic systems- Fuzzy Control Systems, Control strategies and stability analysis-Case Studies, Real-world applications of fuzzy inference in robotic systems.	
Module-3 - Fuzzification and Defuzzification	***8 Hour***
Features and Development of the Membership Function and its types- Fuzzification- Defuzzification to Crisp Sets- λ-cuts for Fuzzy Relations-Defuzzification to Scalar- Membership Value Assignments-Intuition, Inference, Rank Ordering, Inductive Reasoning.	
Module-4 - Hybrid Learning	***6 Hour***
Adaptive Neuro Fuzzy Inference Systems (ANFIS), Architecture – Hybrid Learning Algorithm- Dempster-Shafer Theory in Robotic Decision Making- Fuzzy Bayesian Decision Method in Robotics- Fuzzy c-Means Algorithm- Fuzzy Cognitive Mapping.	
Module-5 – Expert System	***6 Hour***
Introduction to Expert Systems, Components, knowledge representation, and reasoning- Evolutionary Algorithms in Robotic Intelligence- Hybrid Systems, Integration of Fuzzy Logic, Expert Systems, and Neural Networks in Robotics-Fuzzy control optimization using Genetic Algorithm-Case studies	

Laboratory Practice:	*30 Hour*
Fuzzy logic Lab Exercises (Use Suitable Software's): 1. *Employing a fuzzy logic methodology to develop algorithms for forecasting wear rates in tribology- case study analysis.* 2. *Exploring fuzzy logic applications in the Automotive Industry through case studies- An analytical perspective.* 3. *Examining the applications of fuzzy logic in Robot Painting through case studies- a comprehensive analysis.* 4. *Create a basic fuzzy control system for managing the operation of a washing machine- a Case studies.* 5. *Utilize fuzzy logic for brake control in critical scenarios based on the car's speed and acceleration-a Case studies.*	6. *Optimization of milk production in manufacturing through fuzzy logic control-a Case studies.* 7. *Virtual Health Monitoring System employing a Fuzzy Logic Expert System- a Case studies.* 8. *Utilizing ANFIS for Intelligent Robotic Navigation System- a case studies.* 9. *Design and Fuzzy Control of a Robotic Gripper for Optimized Apple and Strawberry Harvesting.* 10. *Implementing Adaptive Fuzzy Control for Precision and Position Control in Industrial Robots.*

Learning Resources	1. *Timothy J. Ross, Fuzzy logic with engineering applications, John Wiley & Sons Ltd, UK, 2nd Editon, 2004, ISBN 0-470-86074-X.* 2. *John Yen and Reza Langari, Fuzzy Logic: Intelligence, Control, and Information, Pearson; 1st edition, 1998, ISBN: 978-0135258170.* 3. *F. Martin McNeill and Ellen Thro, Fuzzy Logic: A Practical Approach"1994, Academic Press Inc, ISBN- 978-0124859654.* 4. *George J.KlirBo Yuan - Fuzzy sets and Fuzzy logic theory and Applications, PHI, 1995.* 5. *Joseph C. Giarratano, Gary D. Riley, Expert Systems: Principles and Programming, Course Technology Inc, 2004, ISBN: 978-0534384470*	6. *Russell Stuart, Norvig Peter, "Artificial Intelligence Modern Approach", Pearson Education series in AI, 3rd Edition, 2010.* 7. *Hans Paul Schwefel, "Evolution and Optimum Seeking", Wiley-Interscience, 1995.* 8. *https://link.springer.com/chapter/10.1007/978-1-4615-2353-6_6* 9. *H. R. Parsaei, Mohammad Jamshidi, Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks, to Fuzzy Logic, Prentice Hall PTR, 1995* 10. *Dan.W. Patterson, "Introduction to Artificial Intelligence and Expert Systems", PHI Learning, 2009*

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
1Mr.S.Prabhu Shankar, DXC Technologies, Chennai	*1. Dr. N.Arunachalam, Associate Professor, IIT Madras*	*1. Prof.S.Prabhu, SRMIST*
	2. Prof. P.Hariharan, Professor, Anna University, CEG campus, Chennai	*2.Mr.V.Manojkumar, SRMIST*

Course Code	21MEE530J	Course Name	FINITE ELEMENT ANALYSIS	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:	*find the approximate solution of boundary value problems*
CLR-2:	*develop basic finite element concepts and solution procedure for one dimensional problems*
CLR-3:	*find the finite element solution for two and three 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 problems using finite element method.*

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	*solve the differential equations using weighted residual and variational approaches*	3		2
CO-2:	*solve the structural analysis problems, such as bar, truss, beam using 1D element.*	3		2
CO-3:	*analysis of two-dimensional structural problems and three dimensional problems*	3		2
CO-4:	*solve Eigen Value and forced vibration problems using finite element method*	3		2
CO-5:	*solve one dimensional heat transfer and fluid flow problems using finite element method*	3		2

Module-1: Solution of Differential Equations **12 Hour**

FEM Applications, Commercial FEM software packages, Solution of differential equations by Weighted residual and variational methods – Collocation, Sub-domain, Least Squares, Galerkin methods - Variational formulation approach- Rayleigh-Ritz method, Principle of minimum potential energy. Solution of differential equations by Galerkin's finite element method

Module-2: One Dimensional structural Analysis **12Hour**

Spring element- stiffness matrix, simple problems with spring element- 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, Gaussian quadrature integration

Module-3: Finite Element Analysis of Two and Three-Dimensional Problems **12 Hour**

Theory of 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-axis symmetric problems-bending of plates- Three dimension elements- Tetrahedron and Hexahedron elements- derivation of shape function and element matrices – Implementation of software packages for two and three dimensional problems.

Module-4 : Dynamic Analysis of Structures **12 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 by Numerical time integration – Finite Difference method, Runge-Kutta method, Newmark's method – Implementation of software packages for modal analysis of plates

Module-5: Heat Transfer and Fluid Flow Problems **12 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

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%	-	-	-	10%	-
Level 2	Understand	10%	-	-	-	10%	-
Level 3	Apply	40%	-	-	40%	40%	-
Level 4	Analyze	40%	-	-	40%	40%	-
Level 5	Evaluate	-	-	-	20%	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Parameswaran, Nokia, Chennai	*1. Dr. Raju Abraham, NIOT, Chennai.*	*1. Dr.P. Nandakumar, SRMIST*

Course Code	21MEE621J	Course Name	OPTIMIZATION WITH APPLICATIONS IN ROBOTICS	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:	*understand the principles of optimization and its requirements in engineering*
CLR-2:	*familiarize with various classical optimization techniques*
CLR-3:	*familiarize with metaheuristic optimization techniques for solving problems*
CLR-4:	*understand the evolutionary algorithms and multi-objective optimization techniques*
CLR-5:	*familiarize the application areas of optimization techniques in robotics*

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	*acquire knowledge on basic optimization problems in engineering*	2	2	
CO-2:	*acquire knowledge on single and multivariate optimization problems using classical optimization tools*	2	2	
CO-3:	*recognize and analyse engineering problems using various metaheuristic optimization techniques*	2	2	
CO-4:	*understand multi-objective optimization using evolutionary algorithms*	2	2	
CO-5:	*analyse the applications of optimization tools in the field of robotics*	2	2	

Module	Hours
Module-1 - Introduction Optimization Techniques	***10 Hour***
Introduction to optimization, Statement of an optimization problem; Formulation of objective function and design constraints; Single variable optimization techniques; Classical optimization for multivariable Basics of maxima and minima convex optimization; Important classes of convex optimization problems.	
Module-2 - Classical Optimization Techniques	***10 Hour***
General Approach golden section Fibonacci method; Random jump method, Random Walk method, Hooke and Jeeves method, Powells method; Quadratic interpolation method, Cubic interpolation method; Conjugate gradient method, Fletcher -Reeves method, Quasi -newton methods, Goal attainment method.	
Module-3 - Metaheuristic Optimization Algorithm	***15 Hour***
Heuristic vs metaheuristic search; single solution vs population-based search; comparison with classical optimization; Nature-inspired and metaphor-based metaheuristics; Simulated annealing, Swarm intelligence, ant colony optimization, particle swarm optimization; Introduction to evolutionary algorithms; genetic algorithm.	
Module-4 - Multi-Objective Optimization and Decision Analysis	***15 Hour***
Multi-criteria decision analyses, Concept of Pareto optimality, Grey Relational analysis, Analytical Hierarchy Process, TOPSIS; Multi-objective optimization using genetic algorithm, multi-objective optimization for solving engineering problems.	
Module-5 – Applications in Robotics	***10 Hour***
Optimal control of robot; robot path and trajectory optimization, application of genetic algorithm, inverse kinematics problem; application of swarm intelligence; organizing groups of robots.	

Learning Resources	1. *Rao Singaresu.S, "Engineering Optimization – Theory & Practice", New Age International (P) Limited, New Delhi, 2009.* 2. *Kalyanamoy Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall of India Pvt. Ltd., 2006.* 3. *Goldberg. D.E, "Genetic algorithms in search, optimization and machine", Barnen, Addison Wesley,New York, 1989.* 4. *Kalyanmoy Deb, "Multi-Objective Optimization Using Evolutionary Algorithms" Wiley, New York, 2001*	5. *Sean Luke, Essentials of Metaheuristics, Lulu, 2013, available for free at http://cs.gmu.edu/~sean/book/metaheuristics/* 6. *Blum, C., Groß, R. "Swarm Intelligence in Optimization and Robotics" In: Kacprzyk, J., Pedrycz, W. (eds) Springer Handbook of Computational Intelligence. Springer Handbooks. Springer, Berlin, 2015.* 7. *Yuval Davidor, "Genetic Algorithms and Robotics: A Heuristic Strategy for Optimization", World Scientific, 1991.*

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 %	

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Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.	1.	1. Dr Shubhabrata Datta, SRMIST

Course Code	21MEE622J	Course Name	DEEP LEARNING	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:	*familiarize with deep learning tools in engineering and its applications*
CLR-2:	*familiarize with CNN for object detection*
CLR-3:	*understand the concepts of RNN and GAN in engineering problems and its applications*
CLR-4:	*understand the problems on perception and planning of robotics using deep learning*
CLR-5:	*understand the problems on control off robots using deep learning*

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	*recognize and analyse the architecture of and train an MLP*	2	2	
CO-2:	*analyze different CNN model types*	2	2	
CO-3:	*compare the basic concepts of RNN and GAN models*	2	2	
CO-4:	*acquire knowledge on the suitability of specific deep learning methods to various real world data domains*	2	2	
CO-5:	*understand the suitability of specific deep learning methods to various real world data domains*	2	2	

Module	Hours
Module-1 - Perceptron and MLP	***5 Hour***
Perceptrons, XOR Gate; Artificial Neural Networks/ Multilayer Perceptron (MLP); Perceptron Training Rule, Back Propagation Learning; Optimization Techniques, Gradient Descent, Batch Optimization; Activation Functions: Sigmoid, ReLU, Hyperbolic functions.	
Module-2 - Convolutional Neural Network	***7 Hour***
Convolutional Neural Network (CNN), Building blocks of CNN, Kernel filter, Transfer Learning; Momentum Optimizer, RMSProp, Adam; Early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization; Underfitting and overfitting.	
Module-3 - Recurrent Neural Network and Generative Adversarial Network	***7 Hour***
Recurrent Neural Network (RNN), Building blocks of RNN; Special RNN architectures: GRU, LSTM, Seq2Seq models, Attention mechanism; Adversarial Learning Models, Generative models; Generative Adversarial Networks (GAN); Adversarial attacks on Neural Networks.	
Module-4 - Recent Trends and Applications	***5 Hour***
Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN; Autoencoders, Representative learning: Unsupervised pretraining and transfer learning.	
Module-5 – Applications in Robotics	***6 Hour***
Deep Learning applications: Image segmentation, Object detection, Attention model for computer vision tasks, Quality inspection, Natural Language Processing, Speech Recognition, Video Analytics; Applications in perception, planning and control of robots.	
Laboratory Practice:	***30 Hour***

1. Classification of OR and AND datapoints using single-layered perceptron. 2. Comparison between the transfer functions using multi-layered perceptron. 3. Comparison between the number of layers and neurons using multi-layered perceptron. 4. Classification of a multi-category image dataset using CNN model (2 layers of convolutions). 5. Classification of a multi-category image dataset using CNN model (4 layers of convolutions).	6. Data augmentation from a small image set. 7. Anomaly Detection from a sensor dataset using RNN. 8. Training a GAN to learn the mapping from random noise to the Gaussian distribution. 9. Semantic segmentation using U-Net. 10. City image segmentation using E-net.

Learning Resources	1. Good fellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016. (https://www.deeplearningbook.org/) 2. Josh Patterson, Adam Gibson, Deep Learning: A Practitioner's Approach, OReilly, 2017.	3. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009. 4. Artúr István Károly et al. Deep Learning in Robotics: Survey on Model Structures and Training Strategies, IEEE Transactions on Systems, Man, and Cybernetics: Systems, Vol. 51, 2021, pp. 266-279.

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%	-	-	10%-	20%	-
Level 2	Understand	20%	-	-	10%-	20%	-
Level 3	Apply	30%	-	-	40%-	30%	-
Level 4	Analyze	30%	-	-	40%-	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. Shubhabrata Datta SRMIST

Course Code	21MEE623J	Course Name	BIG DATA AND CLOUD COMPUTING	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:	understand the key concepts, characteristics and processing associated with big data
CLR-2:	explore various tools and technologies related to big data processing
CLR-3:	acquire knowledge about different cloud computing models, services, and platforms
CLR-4:	provide exposure about security challenges and cloud-based big data analytics
CLR-5:	realize the application of big data and cloud computing technologies in robotics

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	explain the key concepts and architecture of big data processing	2	-	-
CO-2:	use different tools and frameworks to work with big data	2	-	-
CO-3:	utilize cloud service models and deployment options in various cloud platforms	2	-	-
CO-4:	analyze, process, and manage large-scale datasets in a cloud environment	2	3	-
CO-5:	apply big data analytics and cloud computing technologies in robotics	2	3	-

Module-1 - Introduction to Big Data — ***6 Hour***

Overview of Big Data concepts, Characteristics of Big Data, Challenges and opportunities of big data, Introduction to DBMS, Big Data processing architectures, Parallel Processing, and Data Parallelism

Module-2 - Big Data Technologies and Tools — ***6 Hour***

Hadoop ecosystem: HDFS, MapReduce, Hive, and HBase, Apache Spark for big data processing, NoSQL database, Data ingestion and storage solutions

Module-3 - Cloud Computing Fundamentals — ***6 Hour***

Introduction to Cloud Computing - Cloud service models: IaaS, PaaS, SaaS - Cloud deployment models: Public, Private, Hybrid - Key cloud providers: AWS, Azure, Google Cloud Platform (GCP)

Module-4 - Integrating Big Data with Cloud Computing — ***6 Hour***

Security challenges in Big Data and Cloud Computing, Encryption and access control, Cloud-based Big Data processing platforms, Data analytics and machine learning in the cloud

Module-5 – Big Data and Cloud Computing in Robotics — ***6 Hour***

Role of big data and cloud computing in robotics, Sensor data acquisition techniques in robotic systems, cloud robotics- architecture and frameworks platforms, case studies - integrating big data, cloud computing, and robotics

Laboratory Practice: — ***15 Hour***

1. *Write a Spark program in Python or Scala to perform data transformations.*
2. *Set up an account on a cloud platform (e.g., AWS, Azure, Google Cloud) and create a virtual machine instance.*
3. *Ingest data into a cloud-based storage solution.*
4. *Set up a Hadoop cluster using cloud services.*
6. *Create and manage tables in Hive on a cloud-based Hadoop cluster.*
7. *Write and execute Hive queries for data analysis.*
8. *Use cloud-based machine learning services to train and deploy a simple model.*
9. *Exercise with cloud robotics development environments.*
10. *Apply big data techniques in a robotics application.*

5. Execute a simple MapReduce program.	

Learning Resources	1. Sima Acharya, Subhashini Chellappan," BIG Data and Analytics" Wiley Publication, 2020. 2. Michael Minelli, Michele Chambers, AmbigaDhiraj, "Big Data, Big Analytics - Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley Publication, 2018. 3. Tom White, "HADOOP: The Definitive Guide", O Reilly 2012. 4. Achari, Shiva "Hadoop Essentials" Birmingham, UK: Packt Publishing. 2015. 5. Bill Chambers, Matei Zaharia, "Spark: The Definitive Guide", O Reilly 2018. 6. Dan C. Marinescu,"Cloud Computing Theory and Practice", Second Edition, Elsevier, 2018 7. Thomas Erl, Richardo Puttini and Zaigham Mahmood, "Cloud Computing: Concepts,Technology & Architecture", Prentice Hall/PearsonPTR, Fourth Printing, 2014	8. Rajkumar Buyya, James Broberg, AndrzejGoscinski, Cloud Computing Principles and Paradigms, Wiley Publications, 2017. 9. ArshdeepBahga, Vijay Madisetti, "Cloud Computing: A Hands-On Approach", University Press, 2016. 10. K. Chandrasekaran, "Essentials of Cloud Computing", Chapman and Hall/CRC Press, 2014. 11. Sandhya Makkar, K. Martin Sagayam, and Rohail Hassan, "Robotics and Automation in 12. Industry 4.0", CRC Press, 2024

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%	-	-	10%-	20%	-
Level 2	Understand	20%	-	-	10%-	20%	-
Level 3	Apply	30%	-	-	40%-	30%	-
Level 4	Analyze	30%	-	-	40%-	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, Professor, IIT Madras	1. Dr. D. Selwyn Jebadurai, SRMIST
	2. Dr. P. Hariharan, Professor, Anna University	2. Mr. V. Manoj Kumar, SRMIST

Course Code	21MEE624P	Course Name	ROBOT SYSTEM DESIGN	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:	*understand the fundamentals in Geometric modeling.*
CLR-2:	*understand about surface and geometric modelling.*
CLR-3:	*understand the concepts of Robot Cell Design, Control and safety considerations in the real time modelling.*
CLR-4:	*understand the concepts of workspace analysis in robot system design.*
CLR-5:	*understand the concepts of trajectory planning in robot system design.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Programme Outcomes (PO)		
		1	2	3
CO-1:	*apply the basics of Geometric modeling.*	*2*	*1*	*1*
CO-2:	*apply the concepts of surface and solid modelling.*	*2*	*1*	*1*
CO-3:	*apply the concepts of Robot Cell Design, Control and safety considerations in the real time modelling.*	*2*	*1*	*1*
CO-4:	*apply the concepts of workspace analysis in robot system design.*	*2*	*1*	*1*
CO-5:	*apply the concepts of trajectory planning in robot system design.*	*2*	*1*	*1*

Module-1 - Geometric Modeling	***14 Hour***
Types of mathematical representation of curves Wireframe models wireframe entities parametric representation of synthetic curves Hermite cubic splines Bezier curves B-splines, Rational curves	
Module-2 - Surface and Solid Modelling	***14 Hour***
Mathematical representation of surfaces Surface model, surface entities Surface representation, parametric representation of surfaces, plane surface Rule surface, surface of revolution Tabulated cylinder, Solid modeling.	
Module-3 - Robot Workcell Design	***8 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	
Module-4 - Workspace Analysis	***12 Hour***
Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations.	
Module-5 – Trajectory Planning	***12 Hour***
Joint space technique - continuous path motion, Interpolated motion, straight line motion and Cartesian space technique in trajectory planning.	

Learning Resources	1. *Zeid Ibrahim "Mastering CAD/CAM" McGraw Hill international, 2005.* 2. *P.N.Rao, "CAD/CAM: Principles and Applications", Tata McGraw Hill, 2010.* 3. *Mihelj, Matjaž, et al. Robotics. Springer, Cham, 2019.*	4. *Niku, Saeed B. Introduction to robotics: analysis, control, applications. John Wiley & Sons, 2020.* 5. *Bruno Siciliano, et al. Robotics Modelling, Planning and Control, Springer, 2009* 6. *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) Formative CLA-1 Average of unit test (20%)		Project Based Learning CLA-2 (60%)		Report and Viva Voce (20%)		Summative Final Examination (0% weightage)	
		Theory	Practice	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. *Dr. J. Daniel Glad Stephen, SRMIST*
		2. *Mr. V. Manoj Kumar, SRMIST*

Course Code	21MEE625T	Course Name	REHABILITATION AND MEDICAL 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:	*recognize the need of medical robots*
CLR-2:	*familiarize the concept of tracking and localization*
CLR-3:	*illustrate the design concept of medical robots*
CLR-4:	*explain the details of robots in surgery*
CLR-5:	*elaborate the application of robotics in medical practice*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Programme Outcomes (PO)		
		1	2	3
CO-1:	*identify various medical robots and their potential applications.*	3	-	1
CO-2:	*recognize the position tracking and hybrid systems.*	2	-	1
CO-3:	*apply Robotics and its concepts in medical field*	2	-	2
CO-4:	*estimate the application of Medical Robots in various surgical procedures*	2	-	1
CO-5:	*Design a medical robotic system for Rehabilitation and Medical care.*	3	2	1

Module-1 - Introduction — ***9 Hour***

Introduction to medical robotics - Types of medical robots - Navigation - Motion Replication - Potential impact of medical robots, level of human intervention - Interventional radiology for engineers - Rehabilitation and Prosthetics – State of art of robotics in the field of healthcare - DICOM – Teleoperated robots - growing healthcare challenges.

Module-2 - Localization and Tracking — ***9 Hour***

Medical sensors - Position, Range and velocity sensors - Tracking -Tracking - Mechanical linkages- Fiber optic tracking systems - MIS Robot design concepts - Image processing and analysis - Medical imaging modalities - Robot compatibility with medical imagers - Image segmentation and modeling - Tracking devices

Module-3 - Design of Medical Robots — ***9 Hour***

Medical robots: History - Automation and Navigation Challenges - Characterization of gestures to the design of robots - Design methodologies - Technological choices - Development of surgical robotics systems- Perceptual docking for synergistic control- Parallel manipulator - Hyper redundant and continuum Robots.

Module-4 - Robot Assisted Surgery — ***9 Hour***

Minimally invasive surgery and robotic integration - Development of surgical robotics systems - Perceptual docking for synergistic control - Radiosurgery - Orthopedic Surgery - Urologic Surgery and Robotic Imaging - Cardiac Surgery -Neurosurgery - Surgical navigation Calibration Rigid and non-rigid registration

Module-5 – Rehabilitation Robotics — ***9 Hour***

Physiological basis of neuromata recovery - Framework for neuro-rehabilitation robotics: implication and recovery - Actuators and sensors and prosthetic robots - Existing orthopedic robotic systems - Knee replacement surgery - Rehabilitation for Limbs - Robots in Physiotherapy - Rehabilitation and wearable robots -Brain Computer Interface Robot - Autism Robot - hand case studies

Learning Resources	1. *Achim Ernst Floris Schweikard, "Medical Robotics", Springer, 2016.* 2. *Paula Gomes, "Medical robotics Minimally invasive surgery", Woodhead, 2013* 3. *Jaydev P Desai, Rajni V Patel, Antoine Ferreira; Sunil Kumar Agrawal, "The* 4. *Encyclopedia of Medical Robotics", World Scientific Publishing Co. Pvt. Ltd, 2019.*	5. *Jocelyne Troccaz , "Medical Robotics", John Wiley & Sons Incorporated, 2013.* 6. *Vanja Bonzovic , "Medical Robotics", I-tech Education publishing, Austria, 2008.* 7. *Farid Gharagozloo "Robotic Surgery", Springer, 2022.*

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. Vengadesan Vellu, LogFuze Tech, Chennai	1. Dr. A. Queen Alice, AIIMS, Kalyani, West Bengal	1. Dr. A. Arul Jeya Kumar, SRMIST
2.Mr.Jeffrey Charles, Joisy Technologies Private Limited	2. Dr. A. Bazil Raj, DIAT, Pune.	2. Mr. V. Manojkumar, SRMIST

Course Code	21MEE626J	Course Name	CONNECTED ROBOTS	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:	*provide a foundational understanding of autonomous and connected robots*
CLR-2:	*equip a comprehensive understanding of wireless communication standards*
CLR-3:	*analyze the dynamic obstacle avoidance and reactive navigation techniques*
CLR-4:	*develop knowledge to implement effective security measures, promote a culture of cybersecurity awareness and resilience within connected robot ecosystems.*
CLR-5:	*leverage machine learning techniques for enhancing autonomy and intelligence in robotic systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Programme Outcomes (PO)		
		1	2	3
CO-1:	*analyze the characteristics of autonomous and connected robots,*	3	-	-
CO-2:	*evaluate various wireless communication standards and networking protocols for connected robots, and integration with IoT platforms.*	3	-	1
CO-3:	*assess techniques for perception, localization, and navigation in connected robots.*	3	-	1
CO-4:	*examine cybersecurity threats and vulnerabilities in connected robot ecosystems.*	2	2	2
CO-5:	*explore machine-learning techniques and Design human-robot interaction (HRI) principles for enhancing communication in connected robot systems.*	1	3	2

Module 1: Introduction to Autonomous and Connected Robots	***4 Hour***
Introduction- Autonomous and Connected Robots- characteristics- Historical perspective and key milestones - Applications and challenges of autonomous and connected robots in different domains.	
***Module-2* - Communication Protocols**	***8 Hour***
Wireless communication standards Wi-Fi, Bluetooth, Zigbee, etc- Networking protocols (e.g., TCP/IP, MQTT, CoAP)-Network architectures for connected robots-Integration with IoT platforms- Challenges and considerations in selecting communication protocols for connected robots - Data Management and Analytics - Data collection, storage, and processing in connected robot systems-Big data analytics and machine learning for extracting insights from robot-generated data- Privacy and ethical considerations in handling robot data	
Module-3 - Perception, Localization and Navigation	***8 Hour***
Sensing for Autonomy- Techniques for object detection, recognition, and tracking - Simultaneous Localization and Mapping (SLAM) algorithms-Localization methods such as odometry, landmark-based localization, and particle filters - Path planning algorithms (e.g., A, Dijkstra, RRT) Motion planning techniques for dynamic environments - Decision-making architectures (e.g., finite state machines, behavior trees) - Navigation frameworks (e.g., ROS Navigation Stack) - Local and global path planning for robot navigation - Dynamic obstacle avoidance and reactive navigation*	
Module-4 - Cybersecurity for Connected Robots	***4 Hour***
Threats and vulnerabilities in connected robot ecosystems -Security measures for protecting robot systems from cyber-attacks -Best practices for secure design and deployment of connected robots	
Module-5 - AI and Machine Learning in Robotics Human-Robot Interaction (HRI) in Connected Environments	***6 Hour***
Machine learning techniques for autonomous robots (e.g., supervised learning, reinforcement learning) - Training neural networks for perception and decision-making tasks - Transfer learning and adaptation in robotic systems - Design principles for enhancing HRI in connected robot systems Verbal and non-verbal communication cues -Natural language processing for human-robot dialogue - Multi-modal interaction and integration of sensory feedback	

Laboratory Practice:	*30 Hour*

1. *Sensor Integration: integrate various sensors (e.g., ultrasonic, infrared, camera) onto a robot platform and learn to read sensor data and calibrate sensors for accurate readings.*
2. *Path Planning Algorithms: implement common path planning algorithms such as A*, Dijkstra's, or Rapidly-exploring Random Trees (RRT) to plan efficient paths for a robot to navigate through an environment.*
3. *SLAM Simulation: Using simulation software simulate a robot exploring an unknown environment while simultaneously creating a map using SLAM (Simultaneous Localization and Mapping) algorithms.*
4. *PID Control Tuning: To tune Proportional-Integral-Derivative (PID) controllers for robot motion control to experiment with different gains to achieve stable and responsive control.*
5. *Obstacle Avoidance: implement obstacle avoidance algorithms on a robot platform, utilizing sensor data to navigate around obstacles while moving towards a target destination.*
6. *ROS Navigation Stack: Using the Robot Operating System (ROS), set up and configure the navigation stack for a mobile robot to create maps, set navigation goals, and observe the robot autonomously navigate in a simulated environment.*
7. *Wireless Communication Setup: set up wireless communication between a robot and a base station using Wi-Fi or Bluetooth to establish a communication protocol for transmitting sensor data and receiving commands.*
8. *Image Processing for Object Detection: implement image processing algorithms for object detection using a camera-equipped robot to detect and localize objects of interest in the robot's environment.*
9. *Machine Learning for Object Recognition: Students train machine learning models (e.g., convolutional neural networks) to recognize objects from sensor data. They deploy these models on the robot for real-time object recognition tasks.*
10. *Behavior-Based Robotics: Students design and implement a behavior-based control system for a robot, where different behaviors (e.g., obstacle avoidance, goal seeking) are executed based on sensor inputs and predefined rules.*
11. *Cloud Robotics Simulation: Students simulate a cloud-connected robot system using cloud robotics platforms such as AWS RoboMaker or Google Cloud Robotics. They deploy and manage robot applications in the cloud environment.*
12. *IoT Integration: Students integrate IoT devices (e.g., environmental sensors, actuators) with a robot platform. They develop software to collect sensor data, transmit it to a cloud server, and perform remote monitoring and control.*
13. *Cybersecurity Assessment: Students assess the cybersecurity vulnerabilities of a connected robot system. They identify potential attack vectors, implement security measures, and conduct penetration testing to evaluate system resilience.*
14. *Human-Robot Interaction Experiment: Students design and conduct experiments to evaluate human-robot interaction in a connected robot environment. They analyze user feedback and interaction patterns to improve robot behavior.*
15. *Autonomous Navigation and Communication in Connected Robots: Real-World Application Development: In a capstone project, students develop a real-world application for an autonomous and connected robot. This could involve tasks such as autonomous navigation in a warehouse environment, home automation, or agricultural robotics.*

Learning Resources	*1. Bekey, George A. Autonomous robots: from biological inspiration to implementation and control. MIT press, 2017.* *2. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo. Robotics: Modelling, Planning and Control. Springer, 2010* *3. McKinnon, Peter. Robotics: everything you Need to know about robotics from beginner to expert. Peter McKinnon, 2015.*	*4. Hu, Guoqiang, Wee Peng Tay, and Yonggang Wen. "Cloud robotics: architecture, challenges and applications." IEEE network 26, no. 3 (2012): 21-28.* *5. Lloyd Brombach. Practical Robotics in C++: Build and Control Autonomous Robots Using Raspberry Pi 4 and C++, BpB Publication, 2021* *6. Morgan Quigley, Brian Gerkey, and William D. Smart. Programming Robots with ROS: A Practical Introduction to the Robot Operating System, O reily Media, Inc, 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%*	-	-	*10%-*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*10%-*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*40%-*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*40%-*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Venkadesan Velu Founder & CEO @ LogFuze Inc, Chennai	1. *Dr. A. Bazil Raj, DIAT, Pune.*	1. *Dr. M. Prakash, SRMIST*
	2. *Dr. ASS Balan, NIT, Surathkal*	2. *Mr V. Manoj Kumar, SRMIST*

Course Code	21MEE627T	Course Name	BIO-INSPIRED AND SOFT 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:	*identify the fundamental concepts of Bio inspired Robotics*
CLR-2:	*be familiar with applications of bio inspired Robotics*
CLR-3:	*be familiar with the concepts of soft materials*
CLR-4:	*be familiar with the concepts of soft Actuators and Sensors*
CLR-5:	*utilize the Soft Robot in different applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Programme Outcomes (PO)		
		1	**2**	**3**
CO-1:	*apply the fundamental concepts on bio inspired robotics*	*1*	-	*2*
CO-2:	*demonstrate the application of bio inspired robotics*	*1*	*1*	*3*
CO-3:	*apply the fundamental concepts on soft materials*	*3*	-	*3*
CO-4:	*analyze various actuation and sensing capabilities of soft robot*	*3*	-	*3*
CO-5:	*construct soft robot for various industrial applications*	*1*	*3*	*2*

Module-1 - Introduction to Bio Inspired Robotics	***9 Hour***
Introduction to biologically inspired Robotics- Evolutionary Robotics-Biomimicry in Robotics- Bio-inspired Locomotion- Bio-inspired Soft Hands- Bio-hybrid Systems- Integration of Bio-inspired and Soft Robotics.	
Module-2 – Applications of Bio Inspired Robotics	***9 Hour***
Bionic fitness cycle-Robotic Fish-Bio inspired Humanoid Robot neck-Nanorobotics manipulation for biological cell- Measurement of Brain activity robot-Hand motion control using EMG- Hand rehabilitation system.	
Module-3 – Introduction to Soft materials	***9 Hour***
Introduction to Soft Robotics - Definition, types and recent developments-biological analogy- Silicon Elastomers and moulding, Thermoplastics and textiles. Biological Gripping- Bio Inspiration- Types - Soft Robot- Role of Smart material– Classification of compliant Material -Elastomers -Dielectric Elastomers -Fluid Materials – Hydrogels.	
Module-4 – Soft Actuators and Soft Sensors	***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. *Soft resistive, capacitive, and inductive sensing, Soft optical and ionic sensing- soft sensor for strain, force and contact.*	
Module-5 – Soft Robot Applications	***9 Hour***
Manufacturing methods, Silicone mould, 3D printing and fabric welding methods- Soft robotics in rehabilitation and Healthcare applications, Food and Agriculture- E-Textiles- Wearable Soft Robots- locomotion robots-Soft gripper applications.	

Learning Resources	1. *Yunhui Liu and Dong Sun, Biologically inspired robotics, CRC Press, 2012.* 2. *Jean-Arcady Meyer, Agnès Guillot, Biologically Inspired Robots, Springer Handbook of Robotics, 2008, ISBN : 978-3-540-23957-4.* 3. *Gareth J. Monkman, "Soft Robotics", Bentham Books, 2022, ISBN: 978-981-5051-73-5* 4. *Ali Shafti & Ali Shiva, "Soft and Stiffness-controllable Robotics Solutions Euro span, 2018* 5. *Matthew Borgatti, "Soft Robotics: A DIY Introduction to Squishy, Stretchy, and Flexible Robots", Make Community, 2018* 6. *Amir Jafari and Nafiseh Ebrahimi, "Soft Robotics in Rehabilitation",1st Edition, Academic Press, 2021. ISBN:0128185384*	7. *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* 8. *https://softroboticstoolkit.com/* 9. *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* 10. *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	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.S.Prabhu Shankar, DXC Technologies, Chennai	1. Dr. N.Arunachalam, Associate Professor, IIT Madras	1. Prof.S.Prabhu, SRMIST
	2. Prof. P.Hariharan, Professor, Anna University, CEG campus, Chennai	2.Mr.V.Manojkumar, SRMIST

Course Code	21MEE628J	Course Name	ROBOTICS FOR INDUSTRIAL AUTOMATION	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 the concepts of automation and robotics*
CLR-2:	*learn the applications of robotics in material handling and assembly*
CLR-3:	*provide the basic knowledge in SCADA in the field of automation*
CLR-4:	*impart adequate knowledge on use of robotics in inspection*
CLR-5:	*learn the knowledge on application of robotics in industry 4.0*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Programme Outcomes (PO)		
		1	2	3
CO-1:	*learn the basic concepts of automation and robotics*	-	2	-
CO-2:	*apply robotics in material handling and assembly operations*	2	-	1
CO-3:	*demonstrate robotics in achieving automated production*	2	-	1
CO-4:	*demonstrate robotics in achieving automated inspection*	2	-	1
CO-5:	*evaluate the applications of robotics in industry 4.0*	2	-	1

Module-1: Introduction to Automation and Robotics ***6 Hour***

Automation - principles and strategies, automated flow lines, transfer & indexing mechanism. Use of PLC controls in Automation Operator control of robots, representing position and orientation, combining translation and orientation

Module-2: Robotics in Material Handling ***6 Hour***

Concepts of material handling - principles and design consideration. Automated guided vehicles. FMS. Automated storage and retrieval systems, Interfacing handling and storage

Module-3: Robotics in Automated Production ***6 Hour***

Application of robots in welding, spray painting, artist painting, machine loading and unloading, Robot for underwater applications, automated production lines

Module-4: Automated Inspection using Robotic vision system ***6 Hour***

Automated Inspection - principles and methods, Coordinate measuring machines. In process inspection, Robotic vision systems, fundamentals of image processing, object recognition and categorization

Module-5: Role of Robotics and Automation in Industry 4.0 ***6 Hour***

I-IoT - fourth industrial revolution, interfacing robotic sensor with I-IoT data logger, establishing communication between PLC with I-IoT data logger, Pros and Cons of robotics in industry 4.0, various challenges and its applications

Lab Practice: ***30 Hour***

1. *Application of Robot in automated assembly*
2. *Application of Robot in automated packaging*
3. *Application of Robot in automated painting*
4. *Application of Robot in automated metal cutting*
5. *Application of Robot in automated welding*
6. *Application of Robot in automated drilling*
7. *Application of Robot in automated colour identification*
8. *Application of Robot in automated shape identification*
9. *Application of Robot in automated script writing*
10. *Integrating robotic vision camera with IoT data logger*

Learning Resources	1. *Deb. S. R. "Robotics Technology and Flexible Automation", Tata McGraw Hill publishing company limited, 2017* 2. *Groover M.P. "Industrial Robotics, Technology, Programming & Application", McGraw Hill Book and Co., 2017* 3. *Robotics, Vision and Control: Fundamental Algorithms in MATLAB® - Peter Corke, Springer Tracts in Advanced Robotics, 2nd Edition, 2017*	4. *Quigley .M, Gerkey B & William D, "Programming Robots with ROS: A Practical Introduction to the Robot Operating Systems", O'Reilly Media, Inc., 2015.* 5. *Robotics and Industry 4.0 https://doi.org/10.1007/978-3-030-14544-6_9* 6. *NPTEL Course: Industrial Automation and Control https://nptel.ac.in/courses/108105088*

Level	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%*	-	-	*10%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*10%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*40%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*40%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Academia	Internal Experts
1. *Mr.S.Paramasivam, Sr.Manager, Renault Nissan*	*1. Dr. N. Arunachalam, Professor, IIT Madras*	*1. Dr.K. Duraivelu, SRMIST*
2. *Mr.P.Kartikeyan, Nokia Solutions & Networks*	*2. Dr.P.Hariharan, Professor, Anna University*	*2. Dr.R.Ambigai, SRMIST*

Course Code	21MEE629J	Course Name	AUGMENTED REALITY AND VIRTUAL REALITY	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:	*equip students with a comprehensive understanding of Augmented Reality*
CLR-2:	*enable students to comprehend the intricacies of tracking technology*
CLR-3:	*understanding virtual reality and its fundamentals.*
CLR-4:	*equip students with the skills and knowledge for creating and manipulating virtual environments*
CLR-5:	*introduce students to Mixed reality concepts and case studies.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Programme Outcomes (PO)		
		1	**2**	**3**
CO-1:	*design Immersive Augmented Reality Experience.*	*3*	-	*2*
CO-2:	*implement tracking technologies for Augmented reality*	*3*	-	*2*
CO-3:	*evaluate Immersive Virtual Reality Experience*	*3*	-	*2*
CO-4:	*simulate Virtual Environments*	*2*	-	*3*
CO-5:	*apply Mixed Reality concepts for real time applications*	*2*	-	*3*

Module-1 – Introduction of Augmented Reality	***6 Hour***
Augmented Reality (AR) – Definition and Scope, History of AR, Examples of AR; Displays – Multimodal Displays; Visual Displays, Projected Displays; Visual Perception – Requirements and Characteristics (Method of Augmentation, Ocularity and Stereoscopy, Focus, Occlusion, Resolution and Refresh Rate, FoV, Viewpoint offset, Brightness and Contrast, Distortions and Aberrations, Latency, Ergonomics, Social Acceptance)	
Module-2 – Augmented Reality Tracking System and Computer Vision	***6 Hour***
Characteristics of Tracking Technology – Physical Phenomena, Measurement Principle, Measured Geometric Property, Sensor Arrangement, Signal Sources, Degrees of Freedom, Measurement Coordinates, Spatial Sensor Arrangement, Workspace Coverage, Measurement Error, Temporal Characteristics; Stationary Tracking System – Mechanical, Electromagnetic, Ultrasonic Tracking; Computer Vision for AR – Marker Tracking, Multiple-Camera Infrared Tracking, Natural Feature Tracking by Detection, Incremental Tracking; Simultaneous Localization and Mapping, Outdoor Tracking..	
Module-3 – Virtual Reality	***6 Hour***
Virtual Reality (VR) – History of VR, Fundamental Concepts and Components of VR. Multiple Models of Input and Output Interfaces in VR; Implications of Perception on VR – Depth Perception, motion precepting and colour perception; Visual Rendering – Ray Tracing and Shading Models, Rasterization; Human Factors in VR, Perceptual training, VR sickness; VR Applications.	
Module-4 – Virtual Reality Development Process	***6 Hour***
Modeling – Geometric Modeling, Kinematics modeling, Object Position, Physical modeling, Collision Detection, Surface Deformation, Force Computation, Force Smoothing and Mapping, Behaviour Modeling, Model Management; VR on the Web & VR on the Mobile.	
Module-5 Mixed Reality	***6 Hour***

Introduction to Mixed Reality, Mixed Reality case studies – Electronic circuit, Virtual classroom room, Interior design, Healthcare; Programming Languages for AR and VR, Introduction to Python-based programming for VR application, Python toolbox for behavioral experiments using the Vizard VR platform.

Laboratory Practice:	***30 Hour***
1. Basic Environment Step *2. Adding and Manipulating Objects* *3. Basic Animation* *4. User Interaction*	*5. Navigating the Environment* *6. Physics Simulations* *7. Navigating a Mobile Robot in a Virtual Warehouse.*

Learning Resources	*1. Sherman, William R., and Alan B. Craig. Understanding virtual reality: Interface, application, and design. Morgan Kaufmann, 2018.* *2. Mealy, Paul. Virtual & augmented reality for dummies. John Wiley & Sons, 2018.* *3. Dieter Schmalstieg, Tobias Hollerer, Augmented Reality, Principles and Practice, Addison Wesley (Pearson Education), 2016.*	*4. Israel, S., and R. Scoble.The Fourth Transformation: How Augmented Reality & Artificial Intelligence Will Change Everything. 2016.* *5. Craig, Alan B. "Understanding augmented reality: Concepts and applications. 2013.* *6. Daniela, L. (2020). New perspectives on virtual and augmented reality. In New Perspectives on Virtual and Augmented Reality. Routledge.*

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. Prof. Seung Nam Min, Dongyan University, South Korea Email: msnijn12@dyu.ac.kr	*1. Dr. S. Murali, SRMIST*
	2. Prof. Kyung-Sun Lee, angwon National University, South Korea Email: ksunlee@kangwon.ac.kr	*2. Dr. S. Prabhu, SRMIST*

Course Code	21MEE630J	Course Name	NATURAL LANGUAGE PROCESSING	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:	*be familiar with the Concepts of NLP*
CLR-2:	*learn the techniques in natural language processing.*
CLR-3:	*gain familiarity with natural language generation*
CLR-4:	*acquire knowledge about machine translation.*
CLR-5:	*explore various retrieval techniques and Lexical Resources*

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Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Programme Outcomes (PO)		
		1	**2**	**3**
CO-1:	*design NLP framework, analyze text.*	*3*	-	*2*
CO-2:	*implement advanced techniques in NLP to create natural language.*	*3*	-	*2*
CO-3:	*design algorithms for natural language generation and simulate the generation of natural language.*	*3*	-	*2*
CO-4:	*implement machine translation models and evaluate their performance through machine translation tasks.*	*2*	-	*3*
CO-5:	*apply information retrieval techniques, Lexical Resources, and analyze the lexical resources for effective retrieval and analysis.*	*2*	-	*3*

Module-1: Introduction to NLP and Language Modeling	***6 Hour***
Introduction to NLP, Origins, and challenges of NLP, Language and Grammar, NLTK -Text Processing Using NLTK Sentence segmentation and Word Tokenization, Processing Indian Languages, NLP Applications, Information Retrieval, Language Modeling: Various Grammar, Based Language Models, Statistical Language Model, Linguistic Resources, Computational tools for text analysis, statistically based techniques for text analysis.	
Module-2: Word Level Analysis and Syntactic	***6 Hour***
Word Level Analysis, Regular Expressions, Finite, State Automata, Morphological Parsing, Spelling Error Detection and correction, Words and Word classes, Part-of-Speech Tagging, NLTK, Syntactic Analysis, Context-free Grammar and Constituency, Parsing and Probabilistic Parsing.	
Module-3: Semantic Analysis and Discourse Processing	***6 Hour***
Semantic Analysis: Meaning Representation, Lexical Semantics, Ambiguity, Word Sense Disambiguation, Discourse Processing, cohesion, Reference Resolution and Coherence Relations, Discourse Coherence and Structure, Representation learning models for local coherence, Global Coherence.	
Module-4: Natural Language Generation and Machine Translation	***6 Hour***
Natural Language Generation, Architecture of NLG Systems, Generation Tasks and Representations, Application of NLG, Machine Translation, Problems in Machine Translation, Characteristics of Indian Languages, Machine Translation Approaches, Translation involving Indian Languages, Types of Machine Translation Systems, Approaches to Machine Translation (MT), Fighting Spam and Existing NLP models for spam filtering.	
Module-5: Advancements in Natural Language Processing	***6 Hour***

Language Learning Models (LLMs)-Transformer Models, BERT, GPT, XLNet, ERNIE, ALBERT, Generative Adversarial Networks (GANs)- Text Generation, Text Style Transfer, Data Augmentation, Dialogue Generation, Adversarial Training, Text-to-Image Synthesis. Information Retrieval, Design features of Information Retrieval Systems, Classical and Non-classical, Alternative Models of Information Retrieval

Laboratory Practice: 30 Hour	
1: Introduction to Python programming and NLTK - Text Processing Using NLTK Sentence segmentation and Word Tokenization, *2: Exercises to remove stop words,* *3: N-Gram model using NLTK.* *4: Exercises to find Indian Phone numbers and US Phone numbers using Regular Expressions in Python.* *5: Building a POS tagger using Brown Corpus and NLTK.* *6: Parsing a raw English Text using NLTK.* *7: Applications using Wordnet: Word Sense Disambiguation using simple rule-based methods*	*8: Identify the pronouns from a raw text,* *9: Design a simple anaphora resolution model using statistical or rule- based approach.* *10: Build a Word Prediction application.* *11: Build a sentence level translation system using parallel text.* *12: Text classification using Bayesian classifier using python libraries.* *13: Exercises to identify TF-IDF scores for a set of text documents.* *14: Exercises using Word2Vec.* *15: Building stemmer using Porter Stemmer and Lemmatizer*

Learning Resources	*1. Tanveer Siddiqui, U.S. Tiwary, ―Natural Language Processing and Information Retrieval‖, Oxford University Press, 2008.* *2. Daniel Jurafsky and James H Martin, ―Speech and Language Processing: An introduction to Natural Language Processing, Computational Linguistics and Speech Recognition‖, 2 nd Edition, Prentice Hall, 2009.*	*3. James Allen, ―Natural Language Understanding‖, 2 nd edition, Benjamin /Cummings publishing company, 1995.* *4. Christopher D. Manning and HinrichSchütze. Foundations of Statistical Natural Language Processing. MIT Press, 1999.* *5. Muskan Garg, Natural Language Processing and Information Retrieval: Principles and Applications (Computational and Intelligent Systems) 1st Edition, By CRC Press 2023*

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**
Mr.S.Prabhu Shankar, DXC Technologies, Chennai	1. Dr. N.Arunachalam, Associate Professor, IIT Madras	1. Dr. Sundar Singh Sivam S.P, SRMIST
	2. Prof. P.Hariharan, Professor, Anna University, CEG campus, Chennai	2. Mr. V.Manoj kumar, SRMIST