Scheme of Teaching and Examination for M.Tech (Autonomous Scheme: 2022)

I SEMESTER – M.Tech in Robotics and Mechatronics

Sl. No.	Course Area	Course Code	Course Name	Teaching Department	Contact Hours / week			Examination				Credits
					Theory	Practical	Tutorial/ SDA	Duration (Hrs.)	CIE Marks	SEE Marks	Total Marks	
					L	P	T/ SDA					
1	BS	22MRM11	Advanced Mathematics	Mathematics	3	0	0	3	50	50	100	3
2	IPC	22MRM12	Robot Programming	ME	3	2	0	3	50	50	100	4
3	PC	22MRM13	Mechatronics System Design	ME	3	0	2	3	50	50	100	4
4	PC	22MRM14	Industrial Robots	ME	3	0	0	3	50	50	100	3
5	PC	22MRM15	3D Printing	ME	3	0	0	3	50	50	100	3
6	PC	22MRM16	Research Methodology and IPR	ME	3	0	0	3	50	50	100	3
7	PC	22MRML17	Robotics Lab	ME	1	2	0	3	50	50	100	2
8	AEC	22AEC18	Online courses	-	Classes and evaluation procedures are as per the policy of the online course providers.							PP
TOTAL					**19**	**4**	**2**	**21**	**350**	**350**	**700**	**22**

Integrated Professional Core Course (IPC): Refers to Professional Theory Core Course Integrated with practical of the same course. The theory part of the IPC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE).

Ability Enhancement Courses Suggested by BOS (ONLINE courses):

Ability Enhancement Courses will be suggested by the BoS.

- These courses are prescribed to help students to enhance their skills in in fields connected to the field of specialization as well allied fields that leads to employable skills. Involving in learning such courses are impetus to lifelong learning.
- The courses under this category are online courses published in advance and approved by the concerned Board of Studies.
- Registration to Ability Enhancement Course shall be done in consultation with the mentor and is compulsory during the concerned semester.
- In case a candidate fails to appear for the proctored examination or fails to pass the selected online course, he/she can register and appear for the same course if offered during the next session or register for a new course offered during that session, in consultation with the mentor.
- The Ability Enhancement Course carries no credit and is not counted for vertical progression. However, a pass in such a course is mandatory for the award of the degree.

BS: Basic Science	**OE** : Open Electives	**CREDIT Definition**
IPC: Integrated Professional Core	**AEC:** Ability Enhancement Course (A pass in AEC is mandatory for the award of the degree)	1 hour Lecture per week per semester = 1 credit
PC: Professional Core	**PRI:** Project & Internship	2 hours Tutorials / SDA per week per semester = 1 credit
PE : Professional Electives	**SDA:** Skill Development Activity 10.08.2023	2 hours Practical / lab per week per semester = 1 credit

Scheme of Teaching and Examination for M.Tech (Autonomous Scheme: 2022)

IV SEMESTER – M.Tech in Robotics and Mechatronics

Sl. No.	Course Area	Course Code	Course Name	Teaching Department	Contact Hours / week			Examination				Credits
					Theory	Practical /Project	Tutorial/ SDA	Duration (Hrs.)	CIE Marks	SEE Marks	Total Marks	
					L	P	T/ SDA					
1	PRI	22MRM41	Project Work Phase -II	ME	0	8	0	3	100	100	200	18
TOTAL					**0**	**8**	**0**	**3**	**100**	**100**	**200**	**18**

Note:

1. Project Work Phase-II:

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -I to complete the Project work. Each student / batch of students shall prepare project document and present a seminar.

CIE marks shall be awarded by a committee comprising of HOD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -II, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

BS: Basic Science	**OE** : Open Electives	**CREDIT Definition**
IPC: Integrated Professional Core	**AEC:** Ability Enhancement Course (A pass in AEC is mandatory for the award of the degree)	1 hour Lecture per week per semester = 1 credit
PC: Professional Core	**PRI:** Project & Internship	2 hours Tutorials / SDA per week per semester = 1 credit
PE : Professional Electives	**SDA:** Skill Development Activity 10.08.2023	2 hours Practical / lab per week per semester = 1 credit

SEMESTER – I			
Course Name	**: Advanced Mathematics**	**Course Code :**	**22MRM11**
Number of Lecture Hours / Week	**: 03**	**CIE Marks :**	**50**
Number of Practical Hours/ Week	**: 00**	**SEE Marks :**	**50**
Total Number of Lecture + Practical Hours	**: 40**	**SEE Duration :**	**3 Hrs**
L:T:P	**: 3:0:0**	**CREDITS :**	**03**

COURSE PREREQUISITES:
The students should have good knowledge of set theory, probability and basic Numerical Techniques.

COURSE OVERVIEW:
Advanced mathematics is a course which provides mathematical techniques in the advanced areas of mathematics like numerical methods, probability distribution and advanced linear algebra that are of at most relevance to the Engineering disciplines. The purpose of this course is to provide the skills and knowledge required to perform mathematical procedures and processes for solution of Engineering problems.

COURSE LEARNING OBJECTIVES (CLO):
At the end of the course the student will be able to:

1. Find the roots of polynomials in Science and Engineering problems.
2. Differentiate and integrate a function for a given set of tabulated data, for Engineering applications.
3. Understand Eigen values and Eigen Vectors to maintain relationships between two variables while solving problems
4. Explore the techniques of linear algebra
5. Apply various mathematical methods involving arithmetic, algebra, to solve problems

MODULES	TEACHING HOURS
MODULE 1: Approximations and round off errors, Roots of polynomial and Transcendental Equation Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Solving polynomial: Graphical method, solving Algebraic equation: Newton- Raphson method, Secant Method. Multiple roots, Simple fixed-point iteration. **Self-Study Component:** Secant Method to evaluate root of Transcendental Equation	**8**
MODULE 2: Numerical Differentiation and Integration Numerical Differentiation for equal width and Numerical Integration: Newton – Cotes and Gauss Quadrature Integration formulae (Simpson 1/3 rule), Romberg integration, Numerical Differentiation (equal width only) Applied to Engineering problems, High Accuracy differentiation formulae.	**8**

Self-Study Component: Numerical Differentiation.	
MODULE 3: System of Linear Algebraic Equations and Eigen Value-vector Problems Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, Iteration Methods. Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method. **Self-Study Component:** Rayleigh Power Method.	**8**
MODULE 4: Probability Distribution and Sampling Theory Discrete Probability distribution and statistical value. Poisson's Process. Normal Distribution. Chi-square test for goodness of fit test (Poisson's, uniform, proportion) Anova and Fishers for sampling analysis. **Self-Study Component:** Discrete Probability Distribution.	**8**
MODULE 5: Linear Transformation Introduction to Linear Transformation, the matrix of Linear Transformation, Orthogonality using G-S method, Least Squares, SVD. **Self-Study Component:** SVD of 2×2 matrix.	**8**
Activity Based Learning: 1. Assignment 2. Presentation of relevant application in Mechanical domain	

Textbooks:

1. Numerical Analysis for Scientists and Engineers, Narosa Publishing House, ISBN: 9788173197864.
2. Calculus of Probability and Probability Distributions - Dr.H.S.SHARMA , Dr.S.S.Chaudhary, student's friends & company, Agra.
3. Linear Algebra: A Geometric Approach, by S Kumeresan, PHI Learning, ISBN: 9788120316287, 9788120316287.

Reference Books:

1. S.S.Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
2. Steven C. Chapra, Raymond P.Canale, Numerical Methods for Engineers, Tata Mcgraw Hill, th 4 Ed, 2002.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engg computation, New Age International, 2003.
4. Linear Algebra by Gilbert Strang.
5. David. C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002
6. Richard L. Burden and J. Douglas Faires, Numerical Analysis, 8th Edition. Student Edition: ISBN-

10: 0- 534-39200-8.
7. Probability and Random Process, by Haribhaskaran
8. Probability, statistics and Random Process , by T. Veerarajan, 3rd edition , Tata-MaGraw-Hill.

COURSE OUTCOMES (COs): At the end of the course, student will be able to

CO1	Understand the basic concepts of linear algebra, numerical methods, and probability distribution.
CO2	Apply the concept of linear algebra, numerical methods, and probability distribution to solve the problems arising in Engineering field.
CO3	Analyze mathematical problems arising in Engineering, using the concepts of linear algebra, numerical methods, and probability distribution in Engineering field.
CO4*	Presentation of application of Mathematics in Engineering Domain.

CO – PO Relevance Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	2		
CO2	2		
CO3	2		
CO4			2
CO	**2**		**2**

SEMESTER – I			
Course Name	**: Robot Programming**	**Course Code :**	**22MRM12**
Number of Lecture Hours / Week	**: 03**	**CIE Marks :**	**50**
Number of Practical Hours/ Week	**: 02**	**SEE Marks :**	**50**
Total Number of Lecture + Practical Hours	**: 40 +20**	**SEE Duration :**	**3 Hrs**
L:T:P	**: 3:0:2**	**CREDITS :**	**04**

COURSE PREREQUISITES:
This course requires the knowledge of industrial robots and sensors.

COURSE OVERVIEW:
This course provides an overview of the structure and methods of robot programming. Also, emphasizes on the programming and analysis of the industrial manipulators using suitable languages.

COURSE LEARNING OBJECTIVES (CLO):

1. To explain Robot programming languages and their features, limitations, and variables.
2. To familiarize with different programming methods and languages.
3. To employ the appropriate programming language to program application specific robots.

MODULES	TEACHING HOURS
MODULE 1: Introduction to Robot Programming Introduction, levels of robot programming, requirements of robot programming language, problems pertaining to robot programming languages, offline programming systems, Central issues in OLP systems, simple programs on robot applications. **Text Book-2:** Ch. 12-12.1, 12.2, 12.4, 12.5, Ch.13- 13.2 **Self-Study Component:** Automating subtasks in OLP systems	**8**
MODULE 2: Methods of Robot Programming Online programming, off-line programming, advantages of off-line programming, lead through methods - powered lead through, manual lead through, Teach pendant, Robot program as a path in space, methods of defining position in space, motion interpolation, WAIT, SIGNAL, and DELAY commands, Branching, capabilities and Limitations of the lead through methods. **Text Book-1:** Ch. 8- 8.1, 8.2, 8.3,8.3.1,8.4, 8.5, 8.6, 8.7 **Self-Study Component:** capabilities of the lead through methods.	**8**
MODULE 3: Robot Languages Textual ROBOT Languages, first-generation and second-generation languages, the structure of a robot language - operating systems, Elements and Functions, constants, variables and other data objects, Motion commands, points in the workspace, End	**8**

effector and sensor commands, computations and operations, program control and subroutines. **Text Book-1:** Ch.9-9.1, 9.2.1, 9.2.2, 9.3, 9.3.1, 9.3.2, 9.4, 9.5, 9.6, 9.7, 9.8. **Self-Study Component:** Communications, and Data processing.	
MODULE 4: Variable Assembly Language II (VAL II) and A Manufacturing Language (AML) General description, Monitor commands, motion command, Hand Control, Configuration Control, interlock commands, INPUT/OUTPUT Controls, Program Control, examples. General description of AML, AML statements, Constant and variables, program control statements, motion commands, Sensor commands, examples. **Text Book-1:** Ch.9B- 9B.1, 9B.2, 9B.3, 9B.4, 9B.5, 9B.6, 9B.7, 9B.8, Chap.9D- 9D.1, 9D.2, 9D.3, 9D.4, 9D.5, 9D.6**.** **Self-Study Component:** Data processing of AML.	**8**
MODULE 5: Discrete Control and Programmable Logic Controllers Discrete Process Control, Logic Control, Sequence Control, Ladder Logic Diagrams, Programmable Logic Controllers, Components of the PLC, PLC Operating Cycle, Additional capabilities of the PLC, Programming the PLC. **Text Book-3:** Ch.9- 9.1, 9.1.1, 9.1.2, 9.2, 9.3, 9.3.1, 9.3.2, 9.3.3, 9.3.4. **Self-Study Component:** Components of PLC.	**8**
<u>Practical Module</u>	
A-Demonstration A1: Robot programming and simulation for palletizing operation uses VAL- II. A2: Robot programming and simulation for pick and place operation using VAL- II.	**20**
B-Exercise B1: Programming and velocity propagation analysis of 2R planar manipulator. B2: Programming and velocity propagation analysis of 3R planar manipulator. B3: Programming and velocity propagation analysis of 3dof anthropomorphic robot. B4: Programming and force propagation analysis of 3dof cylindrical robot.	
C-Structured Enquiry C1: Robot programming for simple assembly operation (insert pin into hole) using WAVE. C2: Robot programming for simple assembly operation (insert pin into hole) using MINI. C3: Robot programming and simulation for Color identification.	
D-Open Ended Experiments D1: Interfacing Servo motor and I/O peripherals.	

Textbooks:

1. Industrial robotics Technology, Programming and Applications, Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey, McGraw Hill Book Company, Special Indian edition 2012.
2. Introduction to Robotics Mechanics and control, Craig. J. J, Pearson, third edition, 27 July 2014.
3. Automation and Production Systems, and Computer Integrated manufacturing, Mikell P Groover, Fourth edition, 22 July 2016.

Reference Books:

1. Robot Programming: A guide to controlling autonomous robots, Cameron Hughes and Tracey Hughes, Que publishing, First edition, 2 May 2016.
2. Programming languages for industrial robots, Christian Blume and Wilfred Jacob, Springer, First edition reprint, 15 December 2011.
3. Industrial Robots Programming: Building applications for the factories of the future, J. Norberto Pires, Springer, First Edition, 12 February 2010.

COURSE OUTCOMES (COs): At the end of the course, student will be able to

CO1	Describe the structure and methods of robot programming with their controllers.
CO2	Use various languages to program a robot for industrial applications.
CO3	Integrate the functions of industrial manipulators and associated automated components using suitable programming languages.
CO4*	Examine the ability of the programmed industrial manipulator using different languages to perform the desired function and prepare a report

CO – PO Relevance Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	2		
CO2			3
CO3	2		2
CO4	-	2	
CO	**2**	**2**	**2.5**

SEMESTER – I			
Course Name	**: MECHATRONICS SYSTEM DESIGN**	**Course Code:**	**22MRM13**
Number of Lecture Hours / Week	**: 3**	**CIE Marks:**	**50**
Number of SDA per Week	**: 2**	**SEE Marks:**	**50**
Total Number of Lecture + SDA Hours	**: 40+20**	**SEE Duration:**	**3 hours**
L:P:SDA	**: 3:0:2**	**CREDITS:**	**04**

COURSE PREREQUISITES:
Student should have knowledge about Basic Electronics Engineering, Sensors and Transducers

COURSE OVERVIEW: Mechatronics system design provides integration of Mechanical Engineering, Electronics, and computers in the design of CNC machine tools, Robots, etc. It gives insight regarding Sensors and their role in design of mechatronics system. Also special emphasis is given to micro- electro mechanical systems which form the core of any Mechatronics system.

COURSE LEARNING OBJECTIVES (CLO) :
1. Understand key elements of Mechatronics system.
2. Understand principles of sensors, its characteristics, interfacing with controller.
3. Understand and develop the concept of PLC system and its ladder programming, and significance of PLC systems in industrial application.

MODULES	TEACHING HOURS
MODULE 1: Introduction to Mechatronic System Design Definition and Introduction to Mechatronics Systems, Measurement Systems, Control ,Systems, Microprocessors Based Controllers and Applications, Real time interfacing and hardware, components for Mechatronics, Definition and classification of transducers, Difference between transducer and sensor, Definition and classification of sensors, Principle of working and applications of light sensors, proximity switches and Hall Effect sensors, Electrical systems, Mechanical switches, Solenoids. **TEXT BOOK1:** Ch.1, Ch.2 -2.1, 2.3 ,2.10 ,Ch.7. **Self Study Component:** DC/AC Motors, Stepper Motors	**08**
MODULE 2: Microprocessor & Microcontrollers Introduction, Microprocessor systems, Basic elements of control systems, Microcontrollers, Microprocessor architecture and terminology-CPU, memory and address, I/O and Peripheral devices, ALU, Instruction and Program, Assembler, Data, Registers, Program Counter, Flags, Fetch cycle, write cycle, state, bus interrupts. Intel's 8085A Microprocessor, basic structure of PLC, Principle of operation, Programming and concept of ladder diagram, concept of latching & selection of a PLC, Industrial Robot, different parts of a Robot Controller, Drive, Arm, End	**08**

Effectors, **TEXT BOOK1:** Ch.19-19.1-19.4,19.11 **REFERENCE BOOK 2:** Ch.8, Ch.15.7 **Self Study Component:** Difference between Microprocessor and Microcontrollers.	
MODULE 3: MEMS and Microsystems Over view of MEMS and Microsystems, Working Principles of Microsystems, Micro sensors, Micro actuation,. Materials for MEMS: Substrate and wafers. **TEXT BOOK 2:** Ch.1, Ch.2-2.7 **Self Study Component:** MEMS With Micro actuators.	**08**
MODULE 4: Micro System Fabrication Process Photolithography, Ion Implantation, Diffusion, Oxidation, CVD, PVD, Epitaxy, Etching, Bulk Micro Manufacturing, Surface, Micromachining, The LIGA Process. **TEXT BOOK2:** Ch.8,9,10. **Self Study Component:** Micro system Design.	**08**
MODULE 5: Fault Finding Fault Detection Techniques, Watch Dog Timer, Parity and Error Coding Checks, Common Hardware Faults, Microprocessor Systems, Emulation and Simulation, **TEXT BOOK 2:** Ch.21 **Self Study Component:** PLC Systems.	**08**
Skill Development Activity: Involve in case studies and field visits/field work or Interact with industry (small, medium and large)	**20**

Textbooks:

1. "Mechatronics" - W. Bolton, Addison Wesley Longman Publication, 2009

2. "MEMS and Microsystems design and manufacture"- HSU -Tata McGraw-Hill Education, 2002

Reference Books:

1. "Mechatronics System Design"- Shetty and Kolk Cengage Learning, second edition, 2012.

2. "Mechatronics"- Mahalik Tata McGraw-Hill Education, 2003.

3. "Mechatronics"- HMT Tata McGraw-Hill Education, 1998.

4. "Introduction to Mechatronics & Measurement systems"- Michel.B. Histand & David. Alciatore, McGraw Hill Higher Education; 2nd Revised edition, 2002.

COURSE OUTCOMES (COs): At the end of the course, student will be able to	
CO1	Describe the fundamentals of Mechatronics system to solve practical problems
CO2	Identify suitable components of mechatronics system for evolving technologies
CO3	Analyze the problems and recommend a suitable mechatronics system by the application of engineering knowledge
CO4*	Design a suitable Mechatronics system for a particular application and prepare a report.

CO – PO Relevance Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	2		
CO2			3
CO3			2
CO4		2	
CO	**2**	**2**	**2.5**

SEMESTER – I		
Course Name	**: INDUSTRIAL ROBOTS**	**Course Code: 22MRM14**
Number of Lecture Hours / Week	**: 3**	**CIE Marks: 50**
Number of Tutorial / Practical Hours / Week	**: 0**	**SEE Marks: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 40**	**SEE Duration:3 Hrs**
L:P:T	**: 3:0:0**	**CREDITS: 3**

COURSE PREREQUISITES:
The students should have basic knowledge pertaining to the fundamentals of robotics.

COURSE OVERVIEW:
An industrial robot commonly refers to a robot arm used in a factory environment for manufacturing applications. Traditional industrial robots can be classified according to different criteria such as type of movement (degrees of freedom), application (manufacturing process), architecture (serial or parallel), and brand. Industrial robots are automated, programmable, and capable of movement on three or more axes.

COURSE LEARNING OBJECTIVES (CLO):
To provide the basic aspects of robot operations and robot motion control techniques and to teach the students about:

1. Application of robots in material handling
2. Application of robots in assembly
3. Application of robots in hazardous environments
4. Performance specification of industrial robot

MODULES	TEACHING HOURS
MODULE 1: Introduction to Robots & Its Applications General considerations in Robot material handling, material transfer application machine loading and unloading, Robot centered cell. **Text Book 1:** Ch.13-13.1, 13.2,13.3 **Self-Study Component:** CNC machine tool loading	**8**
MODULE 2: Search Methods Application of Robots in continuous arc welding, Spot welding, other processing Operation, Limitation of usage of robots in the processing operation. **Text Book 1:** Ch.14-14.1, 14.2, 14.3, 14.4 **Self-Study Component:** Spray coating.	**8**
MODULE 3: Robot Assembly Robot assembly automation parts presentation methods, assembly operation,	**8**

compliance and the Remote center compliance (RCC) Device, assembly system configurations, Adaptable programmable assembly system, designing for robotic assembly inspection automation, robot - manipulated inspection. **Text Book 1:** Ch.15-15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8 **Self-Study Component:** Vision inspection system.	
MODULE 4: Robotics Technology of the Future Robot Intelligence, Advanced Sensor Capabilities, Telepresence, and Related Technologies, Mechanical Design Features, Mobility, Locomotion, and Navigation, The Universal Hand, Systems Integration and Networking **Textbook 1:** Ch.19-19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7 **Self-Study Component:** Household robots	**8**
MODULE 5: Future Applications Characteristics of Future Robot Tasks, Future Manufacturing Applications of Robots, Hazardous and Inaccessible Non-Manufacturing Environments, Service Industry and Similar Applications. **Textbook 1:** Ch. 20- 20.1, 20.2, 20.3, 20.4 **Self-Study Component:** Safety barriers	**8**
Activity Based Learning: The student shall visit the industry/institution to study the behaviors of the robots used in industries.	

Textbooks:

1. "Industrial Robotics Technology, Programming and Applications", Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, and Nicholas G. Odrey, Mc Graw Hill Book Company, 2017.
2. Industrial Robotics-Groover, Weiss, Nagel, McGraw Hill International, 2nd edition, 2012.

Reference Books:

1. Robotic Engineering - An Integrated approach, Klafter, Chmielewski and Negin, PHI, 1st edition, 2009.
2. Introduction to Autonomous Mobile Robots, Roland Siegwart, Illah R. Nourbakhsh, an d Davide Scaramuzza, , 2nd Edition, PHI, 2011.

COURSE OUTCOMES (COs): At the end of the course, students will be able to

CO1	Describe the characteristics of an Industrial robots.
CO2	Identify the robots used for engineering applications.
CO3	Classify and recommend a suitable robot based on the given applications.
CO4*	Choose a suitable industrial robot for a particular application and prepare a report.

CO – PO Relevance Matrix

CO	PO		
	PO1	**PO2**	**PO3**
CO1	2		
CO2			3
CO3			2
CO4		2	
CO	**2**	**2**	**2.5**

SEMESTER – I			
Course Name	**: 3D Printing**	**Course Code:**	**22MRM15**
Number of Lecture Hours / Week	**: 03**	**CIE Marks:**	**50**
Number of Tutorial / Practical Hours / Week	**: 00**	**SEE Marks:**	**50**
Total Number of Lecture + Tutorial/Practical Hours	**: 40**	**SEE Duration:**	**03 Hrs**
L:T:P	**: 3:0:0**	**CREDITS:**	**03**

COURSE PREREQUISITES:
The course requires the knowledge of material science, computer aided design and modeling.

COURSE OVERVIEW:
This course involves the process of joining materials and generating objects from 3D CAD model data. 3D Printing technologies have the potential to extensively transform the nature of manufacturing processes. The main objective of this course is to acquaint students with the concept of 3D Printing, various 3D Printing manufacturing technologies, selection of materials for 3D Printing, modeling of 3D Printing processes, and their applications in various fields.

COURSE LEARNING OBJECTIVES (CLO):

1. To get exposed to the principle methods, areas of usage, possibilities and limitations of 3D printing technologies.
2. To identify the principles of polymerization and powder metallurgy process, extrusion-based system printing processes, sheet lamination processes, beam deposition processes, direct write technologies and Direct Digital Manufacturing.
3. To be familiar with the characteristics of the different materials, process selection, software issues and post processing that are used in 3D Printing.

MODULES	TEACHING HOURS
MODULE 1: Introduction and Stereo Lithography Systems Introduction: Need for the compression in product development, history of RP systems, Survey of applications and classification of RP systems. Stereo Lithography Systems: Principle, Process parameter, Process details, Data preparation, data files and machine details. **Textbook 1:** Ch. 1.1-1.4. **Self-Study Component:** Growth of RP industry	**8**
MODULE 2: Selective Laser Sintering and Fusion Deposition Modeling Selective Laser Sintering and Fusion Deposition Modeling: Type of machine, Principle of	**8**

operation, process parameters, Data preparation for SLS, Principle of Fusion deposition modelling, Process parameter. **Textbook 1:** Ch. 2.3, 3.4, 2.2, 3.3. **Self-Study Component:** Application of SLS.	
MODULE 3: Solid Ground Curing and Laminated Object Manufacturing Solid Ground Curing: Principle of operation, Machine details, Applications. Laminated Object Manufacturing: Principle of operation. Process details. **Textbook 1:** Ch. 2.2, 3.2, 2.4, 3.5. **Self-Study Component:** Application of Laminated object manufacturing.	**8**
MODULE 4: Concept Modelers Concept Modelers: Principle, Thermal jet printer, Sander's model market. Genisys Xs printer, JP system 5, object Quadra systems. **Textbook 1:** Ch. 4.1-4.6. **Self-Study Component:** Application of Concept Modelers.	**8**
MODULE 5: Rapid Tooling and RP Process Optimization Rapid Tooling: Indirect Rapid tooling -Silicone rubber tooling –Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3Q keltool, etc. Direct Rapid Tooling., AIM, Quick cast process, Copper polyamide, Rapid Tool, DMILS, Prometal, Sand casting tooling, Laminate tooling. RP Process Optimization: Factors influencing accuracy. Data preparation errors, Part building errors. **Textbook 1:** Ch. 6.1-6.11, 7.1-7.9, 9.1. **Self-Study Component:** Error in finishing.	**8**
Activity Based Learning: Generation of 3D models and studying its processing time under different orientation.	
Textbooks: 1. "Rapid Manufacturing", D.T. Pham and S.S. Dimov, Springer, 2001 2. "Rapid Prototyping and Tooling" by Hari Prasad and K S Badrinarayan, ISBN: 978-81-923-2065- 6, 1st edition, SIP-Page Turners Publications, Surya Infotainment Products Pvt. Ltd., Bangalore, 2013. 3. Rapid Manufacturing, Flham D.T & Dinjoy S.S Verlog London, 2001	
Reference Books: 1. Rapid prototyping: Principles an Applications, Chua C.K., Leong K.F. and LIM C.S, World Scientific publications, 3rdEd., 2010. 2. Additive Manufacturing Technologies, Ian Gibson, Davin Rosen, Brent Stucker, Springer, 2nd Ed, 2014. 3. Stereo lithography and other RP & M Technologies- Paul F. Jacobs, SME, NY 1996.	

COURSE OUTCOMES (COs): At the end of the course, student will be able to	
CO1	Explain the fundamentals of 3D Printing processes, devices and materials to solve practical problems
CO2	Identify suitable software tools, processes and techniques that enable advanced 3D Printing
CO3	Analyze challenges and recommend a suitable 3D Printing approach by the application of engineering knowledge
CO4*	Design a suitable component that satisfy product development requirements using 3D Printing devices, processes and prepare a report

CO – PO Relevance Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	2		
CO2			3
CO3			2
CO4		2	
CO	**2**	**2**	**2.5**

SEMESTER – I			
Course Name	**: Research Methodology & IPR**	**Course Code:**	**22MRM16**
Number of Lecture Hours / Week	**: 03**	**CIE Marks:**	**50**
Number of Tutorial / Practical Hours / Week	**: 00**	**SEE Marks:**	**50**
Total Number of Lecture + Tutorial/Practical Hours	**: 40**	**SEE Duration:**	**03 Hrs.**
L:T:P	**: 3:0:0**	**CREDITS:**	**03**

COURSE PREREQUISITES:
The course required the basic knowledge of data sampling and regression analysis.

COURSE OVERVIEW:
This course emphasizes on various techniques of research. It involves developing theoretical and conceptual frameworks and writing a review. It sheds light on sampling designs and methods of data collections. This course develops a skill of interpreting results and preparation of research reports and highlights on intellectual property rights.

COURSE LEARNING OBJECTIVES (CLO):

1. To give an overview of the research methodology and explain the technique of defining a research problem.
2. To explain various research designs and their characteristics.
3. To explain the details of sampling designs and different methods of data collections.
4. To explain the art of interpretation and the art of writing research reports and research proposals.
5. To explain various forms of the intellectual property, its relevance and business impact in the changing global business environment.

MODULES	TEACHING HOURS
MODULE 1: Introduction to Research Methodology Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research, Problems Encountered by Researchers in INDIA. Formulating a research problem: The research problem, the importance of formulating a research problem, Sources of research problems, Considerations in selecting research problem, steps in formulating a research problem, The formulation of research objectives. **Text Book 1: Ch. 1, Text Book 2: Ch. 4** **Self-Study Component:** Significance of Research.	**08**

MODULE 2: Review of Literature Introduction, place of the literature review in research, bringing clarity and focus to your research problem, improving your research methodology, broadening your knowledge base in your research area, enabling you to contextualize your findings, how to review the literature, searching for the existing literature, Reviewing the selected literature, developing a theoretical framework, developing a conceptual framework, writing about the literature reviewed. **Text Book 2: Ch. 3** **Self-Study Component:**.	**08**
MODULE 3: Research Design Meaning of Research Design, need for Research Design, features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. Design of Sample Surveys: Introduction, Sample Design, Sampling and Non-Sampling Errors, Sample Survey Vs. Census Survey. **Text Book 1: Ch. 3 and Ch. 4** **Self-Study Component:** Types of Sampling Designs.	**08**
MODULE 4: Data Collection and Interpretation & Report Writing Data Collection: Introduction, Experiments and Surveys, Collection of Primary Data, Selection of Appropriate Method for Data Collection, Case Study Method. Interpretation and Report Writing: Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports. **Text Book 1: Ch. 6 and Ch. 19** **Self-Study Component:** Collection of secondary data.	**08**
MODULE 5: Intellectual Property Rights The Concept of Intellectual Property, Intellectual Property System in India, Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement, Issues covered under TRIPS Agreement, , Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents. **Text Book 3: Ch.1** **Self-Study Component:** Features of the TRIPS Agreement.	**08**
Activity Based Learning: Case Studies on research methodology and/or intellectual property rights.	

Textbooks:

1. "Research Methodology: Methods and Techniques", C.R. Kothari, Gaurav Garg, New Age International(P)Limited, Second Edition, 2019.
2. "Research Methodology a step-by step guide for beginners", Ranjit Kumar, SAGE Publications Ltd., Fourth Edition, 2014.
3. "Study material on Intellectual Property Rights-Law and Practice", The Institute of Company Secretaries of India, 2015.

Reference Books:

1. "Research Methods: the concise knowledge base", William M. K. Trochim, Atomic Dog Publishing, 2005.
2. "Conducting Research Literature Reviews: From the Internet to Paper", Arlene Fink, Sage Publications, 2010.
3. "Law relating to patents, trademarks, copyright designs and geographical Indications", B L Wadehra,, Universal Law Publishing, 2000.

COURSE OUTCOMES (COs): At the end of the course, student will be able to

CO1	Describe the knowledge of research techniques for conducting research studies.
CO2	Apply the knowledge of research process to provide solutions for engineering problems.
CO3	Examine the techniques of research for solving the problems.
CO4*	Investigate the problems using research-based methods, appropriate techniques, resources, and modern tools to provide valid conclusions.

CO – PO Relevance Matrix

CO	PO		
	PO1	**PO2**	**PO3**
CO1	**2**	**-**	**-**
CO2	**-**	**-**	**3**
CO3	**-**	**-**	**2**
CO4	**-**	**2**	**-**
CO	**2**	**2**	**2.5**

SEMESTER –I			
Course Name	**: Robotics Laboratory**	**Course Code:**	**22MRML17**
No. of Lecture Hours / Week	**: 01**	**CIE Marks:**	**50**
No. of Practical Hours / Week	**: 02**	**SEE Marks:**	**50**
Total No. of Lecture + Practical Hours	**: 10+20**	**SEE Duration:**	**03**
L:T:P	**: 1:0:2**	**CREDITS :**	**02**

COURSE OVERVIEW:

Robotics lab will expose the students to the general functioning of a robot. Students will be trained on few general robots and they will be allowed to implement their skills to design special purpose robots.

COURSE OBJECTIVES(CLO):

1. To understand the aspects of robot design and modeling.
2. To familiarize the students with different forms of end effector development based on application.
3. To utilize the appropriate programing language based on end application or requirement.

Sl. No.	EXPERIMENTS	TYPE
1.	Study of components of robots with drive system and end effectors.	Demonstration
2.	Study of different type of links and joints used in robots.	
3.	Design and modeling of pick and place robot (Scara) using motors.	Exercise
4.	Development/assembly of the Cartesian Coordinate robot.	
5.	Modeling of end effectors for products.	
6.	Design of pick and place robot using pneumatics.	
7.	Choice of sensors based on application.	Structured enquiry
8.	Programming for sorting conveyors based on material and color using suitable sensor.	
9.	Programming for actuation of the robot or end effectors using proximity sensor.	
10.	PLC programing with timer-based actuation.	Open-ended Experiment

COURSE OUTCOMES: After conducting the experiment, the student will be able to,	
CO1	Develop a model for automation applications.
CO2	Solve issues using Robot Programming methods and generate a report.
CO3	Analyze and utilize the appropriate programing language based on end application or requirement.

CO – PO Relevance Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	2		
CO2		2	
CO3			2
CO	**2**	**2**	**2**