Shivaji University, Kolhapur

T. Y. B. Tech Syllabus (as per NEP-2020)

Mechanical and mechatronics Engineering
(Additive Manufacturing)

(2026-27)

Dr.A.D.Shinde College of Engineering,Bhadagaon

(Draft Copy)

Shivaji University, Kolhapur

T. Y. B. Tech Syllabus (as per NEP-2020)

Mechanical and mechatronics Engineering
(Additive Manufacturing)

(2026-27)

Semester V

(Draft Copy)

SCHEME OF INSTRUCTION & SYLLABI

Programme Mechanical & Mechatronics Engineering (Additive Manufacturing)

Scheme of Instructions: First Year B.Tech. in Mechanical & Mechatronics Engineering (Additive Manufacturing)

Semester – V

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/Wk	Course Credits	EXAM SCHEME			
									MSE	ISE/CA	ESE	TOTAL
1	PCC	MME0251	Machine Design	3	--	--	3	3	30	10	60	100
2	PCC	MME0252	Sensors, Transducers and Actuators	3	--	--	3	3	30	10	60	100
3	PCC	MME0253	Additive Manufacturing	3	--	--	3	3	30	10	60	100
4	PEC	MME0254	PEC - 1	3	--	--	3	3	30	10	60	100
5	MDM	MME0255	Multi-disciplinary Minor-03	3	--	--	3	3	30	10	60	100
6	OE	MME0256	Open Elective-03	2	--	--	2	2	30	10	60	100
7	PCC	MME0257	Sensor Lab	--	--	2	2	1	-	25	25	50
8	PCC	MME0258	Additive Manufacturing Lab	--	--	2	2	1	-	25	25	50
9	PEC	MME0259	PEC – 1 lab	--	--	2	2	1	-	25	--	25
10	MDM	MME02510	Multi-disciplinary Minor-03 Lab	--	--	2	2	1	-	50	--	50
11	EL	MME02511	Minor Project 01	--	--	2	2	1	-	25	--	25
			Total	**17**	**--**	**10**	**27**	**22**	**180**	**210**	**410**	**800**

L- Lecture T-Tutorial P-Practical

MSE- Mid Semester Examination ISE/CA- In Semester Evaluation/Continuous Assessment ESE- End Semester Examination (For Laboratory End Semester performance)

Course Category	Basic Science Courses (BSC)	Engineering Science Courses (ESC)	Programme Core Course (PCC)	Programme Elective Course (PEC)	Open Elective other than particular program (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Humanities Social Science and Management (HSSM)	Experiential Learning (EL)	Co-curricular And Extracurricular Activities (CCA)
Last Sem. Cumulative Sum	**16**	**16**	**25**	**-**	**10**	**07**	**12**	**-**	**02**
Semester Credits	**-**	**-**	**11**	**04**	**06**	**-**	**-**	**01**	**-**
Cumulative Sum	**16**	**16**	**36**	**04**	**16**	**07**	**12**	**02**	**02**

PROGRESSIVE TOTAL CREDITS: 88+22=110

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Programme Core Course (PCC)				
Title of Course	**Machine Design**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic Mechanical Engineering, Theory of Machine and Analysis of Mechanical Elements

Course Objectives: The objectives of the course is to

1. **Fundamentals of Machine Design:** Understand loads, factor of safety, theories of failure and engineering material selection.
2. **Static Load Design:** Design machine elements such as knuckle joints, levers and power screws under static loading.
3. **Power Transmission Elements:** Design shafts, keys and couplings for safe power transmission.
4. **Fatigue Design:** Apply fluctuating load and fatigue concepts using S–N curves, endurance strength and Goodman criteria.
5. **Rolling Contact Bearings:** Design and select ball and roller bearings based on load, life, speed and reliability.
6. **Sliding Contact Bearings & Tribology:** Understand friction, wear, lubrication and hydrodynamic bearing design.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO I	**Design Fundamentals:** To explain machine design concepts, types of loads, failure theories and material selection.	II
CO II	**Static Load Components:** Students will be able to design basic machine elements like knuckle joints, levers and power screws under static loading.	III
CO III	**Power Transmission Elements:** Students will be able to analyze and design shafts, keys and couplings for safe power transmission.	III
CO IV	**Fatigue Analysis:** Students will be able to analyze components under fluctuating loads using fatigue theories, S–N curves and Goodman criteria.	IV
CO V	**Rolling Bearings:** Students will be able to select and design rolling contact bearings considering load, life and reliability.	III
CO VI	**Sliding Bearings & Tribology:** Students will be able to understand and apply tribological principles in sliding contact and hydrodynamic bearing design.	II

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Fundamentals of Machine Design**		
	Concept of Machine design, Types of loads, Factor of safety- its selection and significance, Theories of failure(Maximum Principle stress, Maximum shear stress and Maximum Distortion Energy), Phases of design of machine elements, Review and selection of various engineering material properties and I.S. coding for ferrous materials, Factors governing selection of Engineering materials.	**CO 1**	**06 Hrs**
Unit 2	**Design of Mechanical Elements**		
	a) Design of machine elements under static loading- Knuckle joint, Turn buckle and bell crank Lever. (Numerical on Knuckle Joint and Bell crank Lever). b) Forms of threads, Terminology of threads, Trapezoidal and Acme thread, Design of power screw and nuts, Introduction to Recirculating ball Screw. (Numerical on Power Screw with Square thread).	**CO 2**	**09 Hrs**
Unit 3	**Design of Shaft, Keys, and Couplings**		
	Design of solid and hollow shafts, splined shafts, ASME code for shaft design, Types and Design of Keys, Types of Couplings, Rigid Coupling, flexible bushed pin type flanged coupling.	**CO 3**	**06 Hrs**
Unit 4	**Design for Fluctuating Loads**		
	Stress concentration - causes and remedies, Fluctuating stresses, S-N. diagram under fatigue load, Endurance limit, Notch sensitivity, Endurance strength- modifying factors, Design for finite and infinite life under reversed stresses, Cumulative damage in fatigue failure, Goodman diagram, Modified Goodman diagram, Fatigue design for components under combined stresses such as shafts, Thin pressure vessels, Beams subjected to point loads etc.	**CO 4**	**07 Hrs**
Unit 5	**Design of Rolling Contact Bearings**		
	Rolling Contact Bearing: Types, Static and dynamic load capacities, Steinbeck's equation(No Derivation), Equivalent bearing load, Load-life relationship, Bearing life, Load factor, Selection of bearing from manufactures catalogue, Ball and Roller bearing, Design for variable load and speed, Bearings with probability of survival other than 90 %. Lubrication and mountings, Dismounting and preloading of bearings, Oil seal and packing.	**CO 5**	**07 Hrs**
	Design of Sliding Contact Bearings		
Unit 6	i. Introduction to Tribological consideration in design Friction, Wear, Lubrication. ii. Sliding Contact Bearing: Bearing material and their properties: Sintered bearing materials, bearing types and their construction details. iii. Hydro-Dynamic Lubrication: Basic theory, Thick and thin film lubrication, Reynolds's equation (**No Derivation)**, Sommerfield Number, Design consideration in hydrodynamic bearings, Raimondi and Boyd method relating bearing variables, Heat balance in journal bearings, Temperature rise	**CO 6**	**07 Hrs**

Note - The ISE/CA is carried out through the Term work.

1) Case study of components (include selection of materials for various components showing their IS codes, composition and properties).
2) Design and Drawing of Knuckle joint.

3) Write ASME code for design of shaft with suitable examples.
4) Study of Ball bearing mountings and its selection preloading of bearings.
5) Write a tribological consideration in design of bearing.

References:

Reference Books	
1	**"Design of Machine Element"**, J.F. Shigley, Tata McGraw Hill Publication.
2	**"Design of Machine Element"** M.F.Spotts, Pearson Education Publication, 6th Edition.
3	**"Mechanical Engineering Design"**, Joseph E. Shigley, Richard G. Budynas, Tata McGraw Hill Publication.
4	**"Fundamentals of Machine Component Design"**, Robert C. Juvinall and Kurt M. Marshek, Wiley India Pvt. Ltd., 6th Edition
5	**"Machine Design – An Integrated Approach"**, Robert L. Norton, Pearson Education Publication, 5th Edition.

Text Books	
1	**"Design of Machine Elements"**, V.B.Bhandari., Tata McGraw Hill Publication, 3rd Edition.
2	**"Machine Design"**, R.K.Jain, Khanna Publication.
3	**"A Textbook of Machine Design"**, R.S. Khurmi and J.K. Gupta, S. Chand Publication.
4	**"Design of Machine Elements"**, V.B. Bhandari, McGraw Hill Education (India) Pvt. Ltd., 4th Edition.
5	**"Design of Machine Elements",** Kamlesh Purohit and C.S. Sharma, PHI Learning Pvt. Ltd.

Year and Semester	Third Year B. Tech - Semester V Mechanical Mechatronics Engineering (Additive Manufacturing)				
Course Category	Programme Core Course (PCC)				
Title of Course	**Sensors, Transducers and Actuators**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisite: Basic Electrical Engg, Basic Electronics Engg, Electrical Machine, signal processing

Course Objectives: The objectives of this course are to:

- Understand the fundamental principles of sensors, transducers, and actuators used in engineering systems.
- Study various sensing mechanisms for mechanical, thermal, electrical, and optical parameters.
- Analyze static and dynamic characteristics of sensors and transducers.
- Learn signal conditioning techniques and interfacing methods.
- Understand different types of actuators and their applications in automation and control systems.
- Apply sensor and actuator concepts in mechanical and mechatronic system design.

Course Outcomes:

COs	After successful completion of this course, students will be able to:	Blooms Taxonomy
CO1	Explain basic concepts, classification, and characteristics of sensors and transducers.	I, II
CO2	Analyze performance parameters and error characteristics of sensors.	III, IV
CO3	Select appropriate sensors for measurement of mechanical and thermal quantities.	III, IV
CO4	Explain working principles of electrical, optical, and smart sensors.	II, III
CO5	Explain working principles of electrical, optical, and smart sensors.	III, IV
CO6	Identify and apply suitable actuators in mechanical and mechatronic systems.	III, IV

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Introduction to Sensors and Transducers**		
	• Definition and classification of sensors and transducers, Active and passive transducers, Primary and secondary transducers • Static characteristics: sensitivity, accuracy, precision, linearity, hysteresis • Dynamic characteristics: time constant, response time, bandwidth • Errors and calibration • Block Diagram and description of Instrumental System • Advantage and Disadvantage and Application of sensor and transducers	CO1	07 Hrs
Unit 2	**Measurement of Mechanical Quantities**		
	• Displacement sensors: Potentiometers, LVDT, RVDT • Strain gauges: working principle, gauge factor, bridge circuits • Force, torque, and pressure sensors • Load cells • Accelerometers and vibration sensors	CO2	07 Hrs
Unit 3	**Thermal and Fluid Sensors**		
	• Temperature sensors: RTD, thermistors, thermocouples • Heat flux and radiation sensors, Bernoulli's Equation • Flow measurement: orifice, turbine, ultrasonic flow sensors, venturi tube • Level sensors: capacitive, ultrasonic, float type, DP cell	CO3	07 Hrs
Unit 4	**Electrical, Optical, and Smart Sensors**		
	• Proximity sensors: inductive, capacitive, photoelectric • Hall effect sensors, Magneto resistive, Magneto transistor, Piezoelectric sensor • Optical sensors and encoders • MEMS sensors • Smart sensors and IOT-based sensors	CO4	07 Hrs
Unit 5	**Signal Conditioning and Data Acquisition**		
	• Signal conditioning: Introduction, Need and function • Wheatstone bridge circuits		07 Hrs

	• Analog to Digital and Digital to Analog converters • Data acquisition systems (DAS): Introduction, Block Diagram and Application • Sensor interfacing with microcontrollers	**CO5**	
	Actuators		
Unit 6	• Classification of actuators • Electrical actuators: DC motors, stepper motors, servo motors • Pneumatic and hydraulic actuators • Piezoelectric actuators • Shape Memory Alloy (SMA) actuators • Applications in automation and robotics	**CO6**	**07 Hrs**

Note - The ISE/CA is carried out through the Assignment on each unit.

Reference Books	
1	Webster, J.G. (Ed.), 3rd Edition, Measurement, Instrumentation, and Sensors Handbook, CRC Press, Boca Raton, FL.
2	Doebelin, E.O., 5th Edition, Measurement Systems: Application and Design, McGraw-Hill, New York.
3	Neubert, H.K.P., 2nd Edition, Instrument Transducers, Oxford University Press, New Delhi.
4	Liptak, B.G., 3rd Edition, Process Measurement and Analysis, Chilton Book Company / CRC Press.
5	Sinclair, I., 3rd Edition, Sensors and Transducers, Elsevier India Pvt. Ltd., New Delhi.

Text Books	
1	Patranabis, D., 2nd Edition, Sensors and Transducers, PHI Learning Private Limited, Delhi.
2	de Silva, C.W., 2nd Edition, Sensors and Actuators: Engineering System Instrumentation, CRC Press, Boca Raton, FL.
3	Sawhney, A.K., 11th Edition, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai & Co., New Delhi.
4	Nakra, B.C. & Chaudhry, K.K., 4th Edition, Instrumentation, Measurement and Analysis, McGraw-Hill Education (India) Pvt. Ltd., New Delhi.
5	Bentley, J.P., 4th Edition, Principles of Measurement Systems, Pearson Education, London.

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Programme Core Course (PCC)				
Title of Course	**Additive Manufacturing**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Computer Aided Design, Basic Mechanical Engineering and Material & Manufacturing Processes

Course Objectives: The objectives of the course is to

1. **Understand AM basics** – Learn principles, history and importance of additive manufacturing.
2. **Know AM technologies –** Identify and differentiate processes like FDM, SLA, SLS and SLM**.**
3. **Learn AM materials** – Study polymers, metals, composites and their selection for AM.
4. **Prepare digital data** – Understand CAD modeling, STL files, slicing and build orientation.
5. **Design for AM** – Apply design principles, optimization and process-specific guidelines.
6. **Explore applications and quality** – Learn industrial uses, post-processing, defects and quality control.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO I	Understand the basic concepts of Additive Manufacturing, its working principle and its advantages and limitations	II
CO II	Understand and compare major Additive Manufacturing technologies (FDM, SLA, SLS, SLM).	II
CO III	Understand and select suitable materials for Additive Manufacturing based on their properties and limitations.	II
CO IV	Understand digital data processing in Additive Manufacturing, including CAD modeling, slicing, and data preparation.	III
CO V	Understand design principles for Additive Manufacturing, including optimization and process-specific guidelines.	III
CO VI	Understand post-processing, quality control, and applications of Additive Manufacturing.	II

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Additive Manufacturing** • Definition, history and evolution of additive manufacturing. • Differences between conventional and additive manufacturing. • Fundamental concept: layer-by-layer fabrication. • Advantages, limitations and industrial relevance.	CO 1	07 Hrs
Unit 2	**Classification of Additive Manufacturing Technologies** • Overview of major additive manufacturing technologies. • Fused Deposition Modeling (FDM) and Stereo lithography (SLA): principles, materials and applications. • Selective Laser Sintering (SLS) / Selective Laser Melting (SLM): principles, materials and applications. • Comparison of technologies: accuracy, speed, cost and material suitability.	CO 2	07 Hrs
Unit 3	**Materials for Additive Manufacturing** • Polymers, metals, composites and ceramics. • Material properties affecting additive manufacturing: mechanical strength, melting point, shrinkage. • Selection criteria for different additive manufacturing processes. • Limitations and challenges in using additive manufacturing materials.	CO 3	07 Hrs
Unit 4	**Digital Data Processing for Additive Manufacturing** • Computer Aided Design (CAD) modeling principles for additive manufacturing • Stereo lithography file creation and pre-processing requirements • Slicing, layer thickness, support structures and build orientation • Common software tools and data preparation workflow	CO 4	07 Hrs
Unit 5	**Design for Additive Manufacturing** • Principles of designing for AM: minimal support, lightweight, complex shapes • Topology optimization and part consolidation • Process-specific design guidelines (FDM, SLA, SLS, SLM) • Limitations and constraints of AM in design	CO 5	07 Hrs
	Post-Processing and Quality in Additive Manufacturing		
Unit 6	• Industrial applications: aerospace, automotive, medical and tooling. • Post-processing techniques: heat treatment, surface finishing and support removal. • Common defects and quality control methods. • Economic, environmental, and sustainability aspects.	CO 6	07 Hrs

Note - The ISE/CA is carried out through the assignments on each topic.

References:

Reference Books	
1	**"Additive Manufacturing"**, Amit Bandyopadhyay, Susmita Bose, CRC Press, Taylor & Francis Group, 3rd edition.
2	**"Additive Manufacturing Fundamentals and Advancements",**Manu Srivastava, Sandeep Rathee, CRC Press, Taylor & Francis Group, 1st edition.
3	**"Additive Manufacturing: Advanced Materials and Design Techniques",** Pulak Mohan Pandey, Nishant Kumar Singh, Yashvir Singh, CRC Press, Taylor & Francis Group, 1st edition.
4	**"Additive Manufacturing: Applications and Innovations",** J. Paulo Davim, Rupinder Singh, CRC Press, Taylor & Francis Group, 1st edition.
5	**"A Concise Encyclopedia of Additive Manufacturing",** Sanjay Kumar, Springer, 1st edition.

Text Books	
1	**"Additive Manufacturing Technology"**, Hari Prasad I, A.V. Suresh, Cengage Learning India Pvt Ltd, **1st Edition**.
2	**"Additive Manufacturing** C.P. Paul, A.N. Jinoop, McGraw Hill Education, **1st Edition**.
3	**"Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing",** Ian Gibson, David W. Rosen, Brent Stucker, Springer, 3rd Edition.
4	**"3D Printing and Additive Manufacturing: Principles and Applications",** Chee Kai Chua, Kah Fai Leong, World Scientific Publishing, 4th Edition.
5	**"Design for Additive Manufacturing",** Martin Baumers, Richard Hague, Peter Reeves, Wiley, 1st Edition.

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective course (PEC-1)				
Title of Course	**Design for Manufacturing and Assembly (DFMA)**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Analysis of Mechanical Elements, Material and Manufacturing Processes.

Course Objectives: The objectives of the course is to

1. To introduce fundamentals and importance of Design for Manufacturing and Assembly in product development.
2. To understand the effect of manufacturing processes, materials, and tolerances on design.
3. To apply Design for Manufacturing principles for various manufacturing processes.
4. To analyze and evaluate product designs using Design for Assembly techniques.
5. To develop cost-effective, reliable, and sustainable product designs.
6. To redesign existing products using DFMA methodologies.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Explain principles and need of DFM and DFA.	II
CO2	Analyze manufacturability issues related to materials and processes.	IV
CO3	Apply DFM guidelines in component and product design.	III
CO4	Evaluate designs using DFA methods to reduce assembly time and cost.	V
CO5	Develop sustainable and economical designs using DFMA tools.	VI
CO6	Redesign existing products for improved manufacturability and assembly.	VI

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to DFMA**		
	• History of DFMA • Product life cycle and role of design • Need for DFMA in modern engineering • Design cost vs Manufacturing cost • Concurrent engineering concept • DFMA benefits for engineers	CO 1	06 Hrs
Unit 2	**Design for Manufacturing (DFM)**		

	• Material selection for manufacturability
	• Material selection for manufacturability
	• Process selection and capabilities
	• Tolerances, surface finish, and standardization
	• Design guidelines for:
	  • Casting
	  • Forming
	  • Machining
	  • Injection molding
	• Introduction to Design for Additive Manufacturing (DFAM)
			08 Hrs

Unit 3	**Design for Manufacturing (DFM)**		
	• Types of assembly: manual, automated, robotic • DFA principles and reduction of part count • Assembly sequence planning • Fasteners and joining methods • Modular design concept • Design for ease of handling and insertion	CO 3	08 Hrs
Unit 4	**DFMA Analysis and Cost Estimation**		
	• Boothroyd–Dewhurst DFA method • Assembly time estimation • Assembly efficiency calculation • Cost estimation techniques • Introduction to DFMA software tools	CO 4	08 Hrs

Unit 5	**DFMA, Sustainability and Product Development**		
	• DFMA in concurrent and lean product development • Design for quality and reliability • Design for ergonomics • Design for environment (DfE) • Design for serviceability and disassembly • Life cycle cost analysis		**06 Hrs**
Unit 6	**Industrial Applications of DFMA**		
	• Cost reduction through DFMA • DFMA in electronics, consumer products and automation systems • Sustainable and lean product design concepts • Application of tools like lean manufacturing, six sigma, poke-yoke, TPM, concurrent engineering in the perspective of DFMA.	**CO 6**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments on each unit. [10 Marks]

References:

Reference Books	
1	Lean Manufacturing: Tools, Techniques and How to Use Them, William M. Feld, CRC Press, 1st Edition
2	Product Design and Manufacturing (A.K. Chitale & R.C. Gupta / PHI Learning)
3	Fundamentals of Design & Manufacturing, Pravin Kumar, M. Ramaswamy, S.K. Kataria & Sons
4	Engineering Design: A Systematic Approach, G. Pahl, W. Beitz, Springer, 3rd Edition
5	Design for Manufacturability Handbook, James G. Bralla, McGraw-Hill, 2nd Edition

Text Books	
1	Fundamentals of Design & Manufacturing (Pravin Kumar & Ramaswamy / S.K. Kataria)
2	Product Design and Manufacturing (A.K. Chitale & R.C. Gupta / PHI Learning)
3	Fundamentals of Design & Manufacturing, Pravin Kumar, M. Ramaswamy, S.K. Kataria & Sons
4	Engineering Design, George E. Dieter, Linda C. Schmidt, McGraw-Hill Education, 5th Edition
5	Product Design for Manufacture and Assembly, Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, CRC Press,3rd Edition

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective course (PEC-1)				
Title of Course	**Computational Fluid Dynamics (CFD)**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisite: Thermal and fluid Engg, C++ numerical methods and programming skills

Course Objectives: The objectives of this course are to:

- Understand the fundamental concepts of fluid flow and heat transfer governing equations used in CFD.
- Develop knowledge of numerical methods for discretization and solution of fluid flow problems.
- Analyze different grid generation techniques and boundary condition treatments.
- Apply CFD methodologies to solve incompressible and compressible flow problems.
- Interpret CFD results for engineering applications using post-processing tools.
- Prepare students for industrial and research-oriented CFD applications.

Course Outcomes:

COs	**After successful completion of this course, students will be able to:**	**Blooms Taxonomy**
CO1	Explain the fundamentals, scope, and applications of Computational Fluid Dynamics.	I,II
CO2	Derive and interpret governing equations for fluid flow and heat transfer.	I,II
CO3	Apply numerical discretization techniques to fluid flow problems.	II,III
CO4	Analyze grid generation methods and boundary condition treatments.	IV,V
CO5	Solve laminar and turbulent flow problems using CFD solution algorithms.	II,III
CO6	Interpret CFD simulation results for real-world engineering applications.	IV,V

Unit No	Content	CO'S	Hours
Unit 1	**Introduction to CFD**		
	• Overview and scope of CFD • Advantages and limitations of CFD • Classification of fluid flows • Applications of CFD in engineering • CFD solution procedure • Comparison of CFD with experimental and analytical methods	CO1	04 Hrs
Unit 2	**Governing Equations of Fluid Flow**		
	• Conservation of mass (Continuity equation) • Conservation of momentum (Navier–Stokes equations) • Conservation of energy, Equation of state • Classification of PDEs (elliptic, parabolic, hyperbolic)	CO2	06 Hrs
Unit 3	**Discretization Techniques**		
	• Need for discretization • Finite Difference Method (FDM) • Finite Volume Method (FVM) • Finite Element Method (FEM) • Comparison of discretization methods	CO3	04 Hrs
Unit 4	**Grid Generation and Boundary Conditions**		
	• Types of grids: structured, unstructured, hybrid • Grid quality and grid independence study • Boundary conditions: inlet, outlet, wall, symmetry • Initial conditions • Stability, convergence, and error analysis	CO4	06 Hrs
Unit 5	**Solution of Flow Problems**		
	• Solution algorithms: SIMPLE, SIMPLER, PISO • Pressure–velocity coupling • Laminar and turbulent flow modeling • Introduction to turbulence models (k–ε, k–ω) • Compressible and incompressible flows	CO5	04 Hrs
Unit 6	**Post-Processing and Applications**		
	• Residual monitoring and convergence criteria • Visualization techniques: contours, vectors, streamlines • Interpretation of CFD results • Case studies: internal and external flows • Industrial applications of CFD • Introduction to commercial CFD software (ANSYS Fluent / Open FOAM – theory only)	CO6	06 Hrs

Note - The ISE/CA is carried out through the Assigenment on each unit.

References:

Reference Books	
1	**Ferziger, J.H., & Perić, M., 3rd Edition, Computational Methods for Fluid Dynamics,** Springer, 2002, ISBN: 978-3540420743
2	**Chung, T.J., 2nd Edition, Computational Fluid Dynamics,** Cambridge University Press, 2010, ISBN: 978-0521769693
3	**Hirsch, C., Numerical Computation of Internal and External Flows,** Butterworth-Heinemann, 2007, ISBN: 978-0750665940
4	**Fletcher, C.A.J., Computational Techniques for Fluid Dynamics,** Springer, 1991, ISBN: 978-3540522522
5	**Tannehill, J.C., Anderson, D.A., & Pletcher, R.H., 2nd Edition,** Computational Fluid Mechanics and Heat Transfer, Taylor & Francis, 1997, ISBN: 978-1560320463
Text Books	
1	**Versteeg, H.K., & Malalasekera, W., 2nd Edition**, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education Limited, 2007, ISBN: 978-0131274983
2	**Anderson, J.D., 2nd Edition, Computational Fluid Dynamics:** The Basics with Applications, McGraw-Hill Education, New York, 1995, ISBN: 978-0070016859
3	**Muralidhar, K., & Sundararajan, T., 2nd Edition,** Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003, ISBN: 978-8173195213
4	**Ghoshdastidar, P.S., Computational Methods in Heat and Fluid Flow,** Tata McGraw-Hill Education, New Delhi, ISBN: 978-0074635049
5	**Patankar, S.V.,** ***Numerical Heat Transfer and Fluid Flow***, Hemisphere Publishing Corporation, 1980, ISBN: 978-0891165224

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective course (PEC 1)				
Title of Course	**Advanced Manufacturing Processes (AMP)**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Material and Manufacturing Processes

Course Objectives: The objectives of the course is to

1. Understand the limitations of conventional manufacturing processes and the need for advanced and non-traditional manufacturing processes.
2. Explain the principles, mechanisms and process parameters of advanced manufacturing processes such as EDM, ECM, LBM, EBM, USM and additive manufacturing.
3. Analyze material removal mechanisms in advanced manufacturing processes and understand their applicability to different materials and industrial requirements.
4. Compare various advanced manufacturing processes in terms of accuracy, surface finish, productivity, cost, and environmental impact.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Explain the principles and working mechanisms of various advanced and non-traditional manufacturing processes.	II
CO2	Analyze material removal mechanisms and process parameters involved in advanced manufacturing processes.	IV
CO3	Compare different advanced manufacturing processes based on accuracy, surface finish, productivity, cost and applications.	IV
CO4	Select appropriate advanced manufacturing processes for specific materials, component geometries and industrial requirements.	III
CO5	Explain chemical and hybrid manufacturing processes for selecting appropriate manufacturing methods in engineering applications.	III
CO6	. Explain the fundamentals of Additive Manufacturing	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Advanced Manufacturing Processes**		
	• Limitations of conventional manufacturing processes need and classification of advanced manufacturing processes. • Mechanical, electrical, chemical, thermal energy based and hybrid processes. • Selection criteria for advanced manufacturing processes. • Applications and advantages	**CO 1**	**05 Hrs**
Unit 2	**Mechanical Energy based Processes**		
	Working principle, tool materials, Process parameters, material removal mechanism, applications, advantages and limitations of • Abrasive Jet Machining (AJM) • Water Jet Machining (WJM) • Ultrasonic Machining (USM)	**CO 2**	**08 Hrs**
Unit 3	**Electrical and Electrochemical Processes**		
	Working principle, tool materials, Process parameters, material removal mechanism, applications, advantages and limitations of • Electrical Discharge Machining (EDM) • Wire- cut EDM (WEDM) • Electrochemical Machining (ECM)	**CO 3**	**08 Hrs**
Unit 4	**Thermal Energy based Processes**		
	Working principle, tool materials, Process parameters, material removal mechanism, applications, advantages and limitations of • Laser Beam Machining (LBM) • Electron Beam Machining (EBM) • Plasma Arc Machining (PAM)	**CO 4**	**08 Hrs**
Unit 5	**Chemical and Hybrid Manufacturing Processes**		
	Working principle, tool materials, Process parameters, material removal mechanism, applications, advantages and limitations of • Chemical Machining (CHM) • Photochemical Machining (PCM) • Hybrid Manufacturing Processes (Concept and examples) • Micro-machining and Nano-manufacturing	**CO 5**	**08 Hrs**

Unit 6	**Additive Manufacturing**		
	• Introduction to Additive Manufacturing. • Additive Manufacturing processes classification. • Materials used in Additive Manufacturing processes. • Advantages, limitations and applications.	**CO 6**	**05 Hrs**

Note - The ISE/CA is carried out through the Assignments/Case study on each unit. [10 Marks]

References:

Reference Books	
1	Advanced Manufacturing Processes, Ian Gibson, David Rosen, Brent Stucker, Springer, 2nd Edition
2	H.S. Shan & P.C. Pandey, Modern Machining Processes, Tata McGraw-Hill
3	Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker, Springer, 3rd Edition
4	Non-Traditional Machining Processes, V.K. Jain, Allied Publishers
5	Unconventional Machining Processes, M. K. Singh, New Age Publishers
6	Advanced Machining Processes, Hassan El-Hofy, McGraw Hill

Text Books	
1	Manufacturing Processes – II, P. K. Mishra, P. Ranganathan, Pearson Education
2	Modern Machining Processes, P.K. Mishra, Narosa Publishing
3	Non-Traditional Machining Processes, V.K. Jain, Allied Publishers
4	Unconventional Machining Processes, M. K. Singh, New Age Publishers
5	Advanced Machining Processes, Hassan El-Hofy, McGraw Hill

Year and Semester	Third Year B. Tech - Semester V Mechanical & Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective Course (PEC)-01				
Title of Course	**Engineering Economics & Costing**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic Mathematics: basic knowledge of algebra, percentages, ratios. Introductory Economics: demand & supply, cost & revenue.

Course Objectives: The objectives of the course are to

1. To introduce the basic concepts and importance of engineering economics in engineering decision making
2. To understand the concept of time value of money and representation of cash flows.
3. To introduce basic methods used for economic comparison of alternatives.
4. To understand investment appraisal methods used in engineering projects
5. To understand economic evaluation of public and social projects.
6. To introduce costing concepts and their role in managerial and engineering decisions.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Students will be able to explain the role of engineering economics in engineering and industrial decisions.	II
CO2	Students will be able to apply cash flows and time value of money to real-life problems.	III
CO3	Students will be able to select suitable alternatives using basic economic comparison methods.	III
CO4	Students will be able to use simple methods to evaluate engineering investments	III
CO5	Students will be able to use benefit–cost concepts to evaluate public projects	III
CO6	Students will be able to explain cost behavior and apply costing concepts in engineering decisions.	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Engineering Economics** • Meaning and scope of engineering economics • Role of economics in engineering and industry • Types of economic decisions in engineering • Micro and macro-economic considerations (basic idea) • Engineering projects and economic feasibility • Ethical and sustainability considerations in economic decisions.	CO1	07Hrs
Unit 2	**Time Value of Money & Cash Flow Concepts** • Concept of time value of money • Present value and future value (conceptual understanding) • Simple and compound interest (concept only) • Time value equivalence • Cash inflow and cash outflow • Cash flow diagrams and time line representation	CO2	07Hrs
Unit 3	**Economic Comparison Techniques** • Meaning of economic alternatives • Present worth comparison (conceptual approach) • Future worth comparison • Comparison of alternatives with equal life • Comparison of alternatives with unequal and infinite life • Deferred investment decisions	CO3	07Hrs
Unit 4	**Investment Decision and Project Evaluation** • Payback period method • Equivalent annual worth method • Rate of return – concept • Internal Rate of Return (IRR) – basic idea • Limitations and misconceptions of IRR • Comparison of investment evaluation methods	CO4	07Hrs
Unit 5	**Public Project Evaluation & Benefit–Cost Analysis** • Characteristics of public projects • Identification of project costs and benefits • Tangible and intangible benefits • Benefit–cost analysis – concept and application • Cost-effectiveness analysis • Social, environmental and sustainability aspects	CO5	07Hrs

Unit 6	**Costing, Depreciation & Economic Decision Making** • Meaning and classification of costs • Fixed cost and variable cost • Product costing and process costing • Standard costing – basic idea • Depreciation: meaning, causes and importance • Break-even analysis (conceptual) • Cost control and cost reduction techniques	**CO6**	**07Hrs**

Note - The ISE/CA is carried out through six Assignments based on six units: [10 Marks]

References:

Reference Books	
1	Engineering Economics by R. Panneerselvam Publication: PHI Learning, 2017 ISBN: 978-9352605586
2	Engineering Economics and Management by S. C. Sharma Publication: Khanna Publishers, 2012 ISBN: 978-8174092465
3	Engineering Economics by S. K. Duggal Publication: McGraw Hill Education India, 2010 ISBN: 978-0070681972
4	Engineering Economics and Cost Analysis by K. K. Dhawan Publication: S. Chand Publishing, 2011 ISBN: 978-8121928632
5	Engineering Economics and Project Management by K. K. Chitkara Publication: Tata McGraw Hill, 2010 ISBN: 978-0070145214

Text Books	
1	Engineering Economics and Costing by N. V. Naidu & T. Krishna Rao Publication: I.K. International Publishing House, 2014 ISBN: 978-9382332835
2	Engineering Economics by R. K. Rajput Publication: Laxmi Publications, 2012 ISBN: 978-8131808146
3	Engineering Economics and Management by K. V. Bhosale & P. K. De Publication: Nirali Prakashan, 2010 ISBN: 978-8190639675
4	Engineering Economics and Accountancy by S. P. Jain & K. L. Narang Publication: Kalyani Publishers, 2013 ISBN: 978-9327245844
5	A Textbook of Engineering Economics by Dr. M. Mahajan Publication: Dhanpat Rai Publications, 2011 ISBN: 978-8187433842

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Multidisciplinary Minor (MDM)-03				
Title of Course	**Fundamentals of Design for Product Manufacturing (FDPM)**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Analysis of Mechanical Elements, Material and Manufacturing Processes.

Course Objectives: The objectives of the course is to

1. Introduce basic concepts of product design and DFMA in an easy and application-oriented way.
2. Help students understand how design decisions affect manufacturing, assembly, and cost.
3. Develop the ability to simplify product design for ease of manufacturing and assembly.
4. Provide basic knowledge of materials, processes, and tolerances used in engineering products.
5. Expose students to DFMA applications in electronics, software-integrated products, and consumer devices.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Explain basic concepts of DFMA and its importance.	II
CO2	Identify design improvements for easier manufacturing and assembly	IV
CO3	Select basic materials and processes for simple product design	III
CO4	Simplify product structures by reducing parts and assembly steps	IV
CO5	Apply basic DFMA tools and guidelines in simple case studies	IV
CO6	Relate DFMA concepts to real-world products in electronics and computing	IV

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to DFMA**		
	• Meaning and importance of DFMA • Product life cycle (simple understanding) • Role of design in product cost • Need of DFMA in modern industries • Examples from electronics and consumer products	**CO 1**	**06 Hrs**
Unit 2	**Basics of Manufacturing and Materials**		
	• Common materials: metals, plastics, composites (basic idea) • Overview of simple manufacturing processes: Casting, Machining, Molding • Selection of material for simple products • Cost considerations	**CO 2**	**08 Hrs**
Unit 3	**Design for Manufacturing (DFM)**		
	• Concept of manufacturability • Simple design guidelines: Avoid complexity, Use standard parts, Reduce machining operations • Design examples from PCB enclosures, mobile parts, etc. • Introduction to process limitations	**CO 3**	**08 Hrs**
Unit 4	**Design for Assembly (DFA)**		
	• Meaning of assembly efficiency • Reducing number of parts • Easy assembly principles: Symmetry, Standard fasteners, Modular design • Manual vs automated assembly (basic idea) • Case study: simple electronic product	**CO 4**	**08 Hrs**
Unit 5	**Tolerances and Product Quality**		
	• Basic concept of tolerance (very simplified) • Why tolerance is important • Fit and assembly issues • Effect of poor design on product quality • Introduction to error reduction	**CO 5**	**06 Hrs**

Unit 6	**DFMA Applications and Tools**		
	• Introduction to simple tools: Lean concept (waste reduction), Poka-Yoke (mistake proofing) • DFMA in: Electronics products, Computer hardware, Consumer appliances • Cost reduction and sustainability basics	**CO 6**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments on each unit. [10 Marks]

References:

Reference Books	
1	Bralla, J. G., *Handbook of Product Design for Manufacturing*, McGraw Hill Publications.
2	Poli, C., *Design for Manufacturing: A Structured Approach*, Butterworth-Heinemann Publications.
3	Ulrich, K. T., & Eppinger, S. D., *Product Design and Development*, McGraw Hill Education.
4	Pahl, G., & Beitz, W., *Engineering Design: A Systematic Approach*, Springer Publication.
5	Dieter, G. E., *Engineering Design*, McGraw Hill International Edition.
6	Design for Manufacturability – Concepts, Standards and Methods by David M. Anderson
7	Design for Manufacturing: Strategies, Principles, and Techniques by Corrado Poli, Andrea C. Ranzi

Text Books	
1	Boothroyd, G., Dewhurst, P., & Knight, W., *Product Design for Manufacture and Assembly*, CRC Press, 3rd Edition, 2010, ISBN: 978-1420089271.
2	Anderson, D. M., *Design for Manufacturability*, Productivity Press, 2nd Edition, 2020, ISBN: 978-1000764963.
3	Chitale, A. K., & Gupta, R. C., *Product Design and Manufacturing*, PHI Learning Pvt. Ltd., New Delhi.
4	Lal, G. K., *Fundamentals of Design and Manufacturing*, S. Chand Publications, New Delhi.
5	Otto, K., & Wood, K., *Product Design: Techniques in Reverse Engineering and New Product Development*, Pearson Education.

Year and Semester	Third Year B. Tech - Semester Mechanical Mechatronics Engineering (Additive Manufacturing)				
Course Category	Programme core Crouse (PCC) Lab				
Title of Course	**Sensors Lab**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25	25	50	

Prerequisite: Basic Electrical Engg, Basic Electronics Engg, Electrical Machine, signal processing

Course Objectives: The objectives of the course is to

1. **Understand** the working principles of various sensors and transducers for mechanical, thermal, fluid, and electrical measurements.
2. **Demonstrate** calibration and measurement of physical quantities like displacement, force, torque, pressure, temperature, and flow.
3. **Operate** electrical, pneumatic, hydraulic, and SMA actuators and understand their applications in automation.
4. **Analyze** static and dynamic characteristics of sensors including sensitivity, linearity, hysteresis, response time, and accuracy.
5. **Interface** sensors and actuators with microcontrollers for basic data acquisition and control experiments.
6. **Develop** practical skills in instrumentation, measurement, and signal conditioning to solve real-world engineering problems.

Course Outcomes:

COs	**After completing this practical course, students will be able to:**	**Blooms Taxonomy**
CO1	Identify and classify various sensors, transducers, and actuators used in mechanical and mechatronics systems.	I,II
CO2	Measure mechanical quantities like displacement, force, torque, and vibration using appropriate sensors and instruments.	II,III
CO3	Measure thermal and fluid parameters using temperature, flow, and level sensors and interpret results.	II,III
CO4	Demonstrate the use of electrical, optical, Hall effect, and smart sensors for practical applications.	II,III,IV
CO5	Interface sensors and actuators with data acquisition systems and microcontrollers to monitor and control physical processes.	IV,V
CO6	Evaluate the performance of actuators (electrical, pneumatic, hydraulic, SMA) in automation and robotics applications.	V,VI

Unit No.	Content	CO'S	Hours
1	**Experiment 1: Study of Displacement Sensor** ● Measure displacement using LVDT. ● Observe the linearity and hysteresis of LVDT.	CO1	4
2	**Experiment 2: Strain Gauge and Load Cell Measurement** ● Connect a strain gauge to a Wheatstone bridge. ● Measure applied load and calculate gauge factor.	CO2	4
3	**Experiment 3: Measurement of Force, Torque, and Pressure** ● Measure force using a load cell. ● Measure torque using a torque transducer. ● Measure pressure using a pressure sensor.	CO3	4
4	**Experiment 4: Study Temperature and Flow Sensors** ● Measure temperature using RTD and thermocouple. ● Observe response of thermistor. ● Measure flow using orifice and turbine flow sensors.	CO4	4
5	**Experiment 5: Understand Proximity, Hall Effect, and Optical Sensors** ● Detect object using inductive/capacitive proximity sensors. ● Use Hall effect sensor to measure magnetic field. ● Read position with optical encoder.	CO5	4
6	**Experiment 6: Study electrical, pneumatic, hydraulic, and Actuator Study and Interfacing** ● Operate DC motor, stepper motor, and servo motor. ● Demonstrate pneumatic or hydraulic actuator operation. ● Observe SMA actuator actuation. ● Interface actuators with microcontroller (optional: Arduino/STM32).	CO6	4

References:

Reference Books	
1	**Webster, J.G. (Ed.),** 3rd Edition, Measurement, Instrumentation, and Sensors Handbook, CRC Press, Boca Raton, FL.
2	**Doebelin, E.O.,** 5th Edition, Measurement Systems: Application and Design, McGraw-Hill, New York.
3	**Neubert, H.K.P.,** 2nd Edition, Instrument Transducers, Oxford University Press, New Delhi.
4	**Liptak, B.G.,** 3rd Edition, Process Measurement and Analysis, Chilton Book Company / CRC Press.
5	**Sinclair, I.,** 3rd Edition, Sensors and Transducers, Elsevier India Pvt. Ltd., New Delhi.

Text Books	
1	**Patranabis, D.,** 2nd Edition, Sensors and Transducers, PHI Learning Private Limited, Delhi.
2	**de Silva, C.W.,** 2nd Edition, Sensors and Actuators: Engineering System Instrumentation, CRC Press, Boca Raton, FL.

3	**Sawhney, A.K.,** 11th Edition, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai & Co., New Delhi.
4	**Nakra, B.C. & Chaudhry, K.K.,** 4th Edition, Instrumentation, Measurement and Analysis, McGraw-Hill Education (India) Pvt. Ltd., New Delhi.
5	**Bentley, J.P.,** 4th Edition, Principles of Measurement Systems, Pearson Education, London.

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Programme Core Course (PCC) Lab				
Title of Course	Additive Manufacturing Lab			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25	25	50	

Prerequisites: Computer Aided Design, Basic Mechanical Engineering and Material & Manufacturing Processes

Course Objectives: The objectives of the course is to

1. **Understand AM machines** – Learn basic operation and safety of AM equipment..
2. **Create CAD models** – Develop simple 3D models for AM applications.
3. **Prepare print data** – Generate STL files and slicing parameters
4. **Fabricate AM parts** – Print components using AM machines.
5. **Perform post-processing** – Carry out support removal and surface finishing.
6. **Inspect printed parts** – Evaluate quality, accuracy and defects

Course Outcomes:

COs	At the end of successful completion of the course, the student will be able to	Blooms Taxonomy
CO1	**Operate additive manufacturing machines safely** and explain their basic working.	III
CO2	**Create suitable CAD models** for additive manufacturing applications.	VI
CO3	**Generate STL files and slicing parameters** for AM part fabrication.	III
CO4	**Fabricate components using AM processes** following correct procedures.	III
CO5	**Perform basic post-processing operations** on printed parts.	III
CO6	**Evaluate printed parts** for dimensional accuracy and common defects.	IV

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Additive Manufacturing Machines and Safety:**		
	Study of AM machine components, working principles, and safety practices.	CO 1	04 Hrs
Unit 2	**CAD Modeling for Additive Manufacturing:**		
	Creation of simple 3D CAD models suitable for AM processes.	CO 2	06 Hrs
Unit 3	**STL File Generation and Slicing:**		
	Conversion of CAD models into STL format and preparation of print parameters.	CO 3	06 Hrs
Unit 4	**Fabrication of AM Component:**		
	Printing of a simple component using an additive manufacturing process.	CO 4	04 Hrs
Unit 5	**Post-Processing of Printed Components:**		
	Removal of supports and basic surface finishing operations.	CO 5	04 Hrs
Unit 6	**Inspection of Printed AM Parts:**		
	Measurement of basic dimensions and visual quality check.	CO 6	04 Hrs

Term work: **[25 marks]**

1. Study of Additive Manufacturing Machine and Safety Practices.
2. CAD Modeling of a Component for Additive Manufacturing
3. STL File Generation and Slicing for Additive Manufacturing.
4. Fabrication of a Component Using Additive Manufacturing Process.
5. Post-Processing of Additively Manufactured Components.
6. Inspection of Additively Manufactured Parts.

References:

Text Books	
1	**"Additive Manufacturing Technology",** Hari Prasad I, A.V. Suresh, Cengage Learning India Pvt Ltd, **1st Edition**.
2	**"Additive Manufacturing"** C.P. Paul, A.N. Jinoop, McGraw Hill Education, **1st Edition**.
3	**"Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing",** Ian Gibson, David W. Rosen, Brent Stucker, Springer, 3rd Edition.
4	**"3D Printing and Additive Manufacturing: Principles and Applications",** Chee Kai Chua, Kah Fai Leong, World Scientific Publishing, 4th Edition.
5	**"Design for Additive Manufacturing",** Martin Baumers, Richard Hague, Peter Reeves, Wiley, 1st Edition.

Reference Books	
1	**"Additive Manufacturing"**, Amit Bandyopadhyay, Susmita Bose, CRC Press, Taylor & Francis Group, 3rd edition.
2	**"Additive Manufacturing Fundamentals and Advancements",**Manu Srivastava, Sandeep Rathee, CRC Press, Taylor & Francis Group, 1st edition.
3	**"Additive Manufacturing: Advanced Materials and Design Techniques",** Pulak Mohan Pandey, Nishant Kumar Singh, Yashvir Singh, CRC Press, Taylor & Francis Group, 1st edition.
4	**"Additive Manufacturing: Applications and Innovations",** J. Paulo Davim, Rupinder Singh, CRC Press, Taylor & Francis Group, 1st edition.
5	**"A Concise Encyclopedia of Additive Manufacturing",** Sanjay Kumar, Springer, 1st edition.

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective course (PEC-1) Lab				
Title of Course	**Design for Manufacturing and Assembly (DFMA) Lab**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25	--	25	

Prerequisites: Analysis of Mechanical Elements, Material and Manufacturing Processes.

Course Objectives: The objectives of the course is to

1. To develop hands-on skills in analyzing product designs for manufacturability and assembly.
2. To enable students to identify and reduce part counts and assembly complexities.
3. To apply tolerance and fit concepts in practical product analysis.
4. To familiarize students with DFMA tools and CAD-based design evaluation.
5. To expose students to industrial case studies and cost-effective design improvements.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Apply DFMA principles to analyze and improve real products.	IV
CO2	Identify and reduce part counts and assembly difficulties in existing designs.	III
CO3	Select appropriate materials and manufacturing processes for improved manufacturability.	III
CO4	Evaluate tolerances, fits and assembly sequences to enhance product quality.	IV
CO5	Utilize DFMA tools and CAD-based methods for practical product redesign.	IV
CO6	Relate practical DFMA applications to industrial case studies for cost and efficiency improvements.	IV

Unit No.	Content	COs	Hours
1	**Study of DFMA Principles Using a Simple Product** Understand DFMA concepts and evaluate product life cycle and design costs.	**CO 1**	4
2	**Tolerance Evaluation and Stack-Up Analysis** Understand functional vs manufacturing tolerances and evaluate their impact on assembly.	**CO 2**	4
3	**Material Selection and Manufacturing Process Mapping** Apply DFM principles to choose suitable materials and manufacturing processes	**CO 3**	4
4	**Product Redesign for Ease of Assembly** Apply DFA principles to redesign a product for simpler assembly.	**CO 4**	4
5	**DFMA Tool Application – Lean / Six Sigma / Poka-Yoke** Use DFMA tools to improve design and process efficiency.	**CO 5**	6
6	**Industrial Case Study Analysis of DFMA** Analyze real-world products for cost reduction and improved design.	**CO 6**	6

References:

Reference Books	
1	Product Design and Manufacturing, Avinash K. Chitale & R.C. Gupta, PHI Learning Pvt. Ltd.
2	Fundamentals of Design and Manufacturing, G.K. Lal, S. Chand Publications
3	Engineering Design & Product Development, P.S. Gill, S.K. Kataria & Sons
4	Lean Manufacturing: Tools, Techniques & How to Use Them, B. Kumar / S. Gupta, Oxford University Press
5	Manufacturing Processes for Engineering Materials, Serope Kalpakjian, Steven Schmid, Pearson Education, 6th Edition

Text Books	
1	Product Design and Manufacturing, Avinash K. Chitale & R.C. Gupta, PHI Learning Pvt. Ltd.
2	Product Design and Development, Karl T. Ulrich, Steven D. Eppinger, McGraw-Hill Education, 7th Edition
3	Product Design for Manufacture and Assembly, Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, CRC Press, 3rd Edition
4	Lean Manufacturing: Tools, Techniques & How to Use Them, B. Kumar / S. Gupta, Oxford University Press
5	Engineering Design, George E. Dieter, Linda C. Schmidt, McGraw-Hill Education, 5th Edition Year: 2013

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective course -01 Lab				
Title of Course	**Computational Fluid Dynamics (CFD) Lab**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25	--	25	

Prerequisite: Thermal and fluid Engg, C++ numerical methods and programming skills

Course Objectives: The objectives of the course is to

1. **Understand** the CFD software interface, workflow, and basic simulation setup.
2. **Apply** numerical methods to simulate laminar and turbulent fluid flow problems.
3. **Analyze** the effect of grid generation, boundary conditions, and solver parameters on solution accuracy.
4. **Simulate** heat transfer and fluid flow phenomena for practical engineering applications.
5. **Interpret** CFD simulation results using post-processing tools for velocity, pressure, and temperature fields.
6. **Develop** skills to prepare detailed CFD reports and present engineering analysis for industrial applications

Course Outcomes:

COs	**After completing this practical course, students will be able to:**	**Blooms Taxonomy**
CO1	Demonstrate proficiency in CFD software for pre-processing, meshing, and solver setup.	I,II
CO2	Perform laminar and turbulent flow simulations and compare numerical results with analytical solutions.	II,III
CO3	Analyze the influence of mesh quality, grid refinement, and boundary conditions on simulation accuracy.	III
CO4	Simulate heat transfer and coupled flow problems for engineering systems	III,IV
CO5	Interpret and visualize CFD results using contours, vectors, streamlines, and plots.	IV,V
CO6	Prepare professional CFD reports and present findings for real-world engineering applications.	IV,V

Unit No.	Content	CO's	Hours
1	**Experiment 1: Introduction to CFD Software** Familiarize with CFD software (ANSYS Fluent / OpenFOAM) interface. • Learn GUI/command-line operations. • Explore geometry creation, meshing, and solver setup. • Run a simple 2D flow simulation (e.g., flow over a flat plate).	CO1	4
2	**Experiment 2: Mesh/Grid Generation Study** Understand structured and unstructured grid generation. • Create structured and unstructured meshes for simple geometries. • Studies mesh refinement effect on solution accuracy (grid independence study).	CO2	4
3	**Experiment 3: Laminar Flow Simulation** Simulate and analyze 2D laminar flow in a channel or pipe. • Solve incompressible laminar flow. • Plot velocity profiles and compare with analytical solutions.	CO3	4
4	**Experiment 4: Turbulent Flow Simulation** Study turbulence modeling in CFD. • Simulate turbulent flow using k–ε or k–ω models. • Compare velocity and pressure distribution for different turbulence models.	CO4	2
5	**Experiment 5: Heat Transfer Simulation** Analyze conduction and convection problems. • Solve 2D heat conduction in a solid block. • Simulate forced convection in a channel. • Compare numerical results with theoretical/analytical solutions.	CO4, CO5	4
6	**Experiment 6: Flow over a Cylinder / Bluff Body** Study external flow and vortex shedding effects. • Simulate flow over a cylinder at different Reynolds numbers. • Visualize velocity contours, streamlines, and pressure distribution.	CO5, CO6	2
7	**Experiment 7 (Optional): Compressible Flow Simulation** Understand supersonic and subsonic compressible flow behavior. • Simulate compressible flow in a nozzle. • Plot Mach number, pressure, and density distributions.	CO6	4

References:

Reference Books:	
1	**Ferziger, J.H., & Perić, M., 3rd Edition, Computational Methods for Fluid Dynamics, Springer, 2002, ISBN: 978-3540420743**
2	**Chung, T.J., 2nd Edition, Computational Fluid Dynamics, Cambridge University Press, 2010, ISBN: 978-0521769693**
3	**Hirsch, C., Numerical Computation of Internal and External Flows, Butterworth-Heinemann, 2007, ISBN: 978-0750665940**
4	**Fletcher, C.A.J., Computational Techniques for Fluid Dynamics, Springer, 1991, ISBN: 978-3540522522**
5	**Tannehill, J.C., Anderson, D.A., & Pletcher, R.H., 2nd Edition, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis, 1997, ISBN: 978-1560320463**
Text Books:	
1	**Versteeg, H.K., & Malalasekera, W., 2nd Edition, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education Limited, 2007, ISBN: 978-0131274983**
2	**Anderson, J.D., 2nd Edition, Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill Education, New York, 1995, ISBN: 978-0070016859**
3	**Muralidhar, K., & Sundararajan, T., 2nd Edition, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003, ISBN: 978- 8173195213**
4	**Ghoshdastidar, P.S., Computational Methods in Heat and Fluid Flow, Tata McGraw-Hill Education, New Delhi, ISBN: 978-0074635049**
5	**Patankar, S.V., *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing Corporation, 1980, ISBN: 978-0891165224**

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective course (PEC 1) Lab				
Title of Course	**Advanced Manufacturing Processes Lab**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25	--	25	

Prerequisites: Material and Manufacturing Processes

Course Objectives: The objectives of the course is to

1. Understand and explore various advanced manufacturing processes through case studies and demonstrations.
2. Apply simulation and study-based techniques to analyze manufacturing processes where full-scale machines are not available.
3. Examine modern manufacturing technologies including micro-manufacturing and 3D printing for rapid prototyping.
4. Gain practical insights into industrial practices through visits and detailed reports on at least one advanced manufacturing process.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Identify and explain the working principles, applications and limitations of different advanced manufacturing processes.	II
CO2	Perform simulations and analyze case studies to understand process parameters, material removal and accuracy in machining operations.	IV
CO3	Demonstrate knowledge of micro-manufacturing techniques and rapid prototyping using 3D printing.	III
CO4	Evaluate industrial setups and prepare detailed reports, linking theoretical concepts to real-world manufacturing practices.	IV

Unit No.	Content	COs	Hours
1	**Case studies, demonstrations, simulations and study-based activities on any four of the following Advanced Manufacturing Processes (where full-scale machines are not available).**		
1.1	Abrasive Jet Machining (AJM)	**CO 1**	4 Hrs
1.2	Water Jet Machining (WJM)		4 Hrs
1.3	Electrical Discharge Machining (EDM)		4 Hrs
1.4	Wire- cut EDM (WEDM)		4 Hrs
1.5	Laser Beam Machining (LBM)		4 Hrs
1.6	Plasma Arc Machining (PAM)		4 Hrs
1.7	Chemical Machining (CHM)		4 Hrs
2	**Case study on Micro-manufacturing in the Electronics industry.**	**CO 2**	4 Hrs
3	**Case study on 3D printing for rapid prototyping.**	**CO 3**	4 Hrs
4	**Industrial visit and its report to study working of at least any one Advanced Manufacturing Process.**	**CO 4**	4 Hrs

References:

Reference Books	
1	Advanced Manufacturing Processes, Ian Gibson, David Rosen, Brent Stucker, Springer, 2nd Edition
2	H.S. Shan & P.C. Pandey, Modern Machining Processes, Tata McGraw-Hill
3	Modern Machining Processes, P.K. Mishra, Narosa Publishing
4	Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker, Springer, 3rd Edition
5	Unconventional Machining Processes, M. K. Singh, New Age Publishers

Text Books	
1	Manufacturing Processes – II, P. K. Mishra, P. Ranganathan, Pearson Education
2	Modern Machining Processes, P.K. Mishra, Narosa Publishing
3	Non-Traditional Machining Processes, V.K. Jain, Allied Publishers
4	Unconventional Machining Processes, M. K. Singh, New Age Publishers
5	Advanced Machining Processes, Hassan El-Hofy, McGraw Hill

Year and Semester	Third Year B. Tech - Semester V Mechanical & Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective course (PEC)-01 LAB				
Title of Course	**Engineering Economics & Costing (lab)**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25	--	25	

Prerequisites: Basic understanding of money, cost, and value, simple idea of time (past, present, future), basic knowledge of profit, loss, and investment

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Course Objectives: The objectives of the course is to

1. To understand the importance of engineering economics in engineering, industry, and society.
2. To understand the concept of time value of money using simple real-life examples.
3. To introduce the concept of cash inflows and cash outflows in simple projects.
4. To understand basic concepts used for comparing economic alternatives.
5. To understand basic investment decision methods and public project evaluation concepts.
6. To introduce basic costing concepts and their role in decision making.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Students will be able to explain the role of engineering economics in making ethical and sustainable engineering decisions.	II
CO2	Students will be able to explain why money has different value at different times.	II
CO3	Students will be able to understand and show cash coming in and going out using simple cash flow diagrams.	II
CO4	Students will be able to understand and explain different options using basic economic comparison ideas.	II
CO5	Students will be able to explain basic investment evaluation methods and identify project costs and benefits.	II
CO6	Students will be able to understand and explain costs, depreciation, and break-even	II

Unit No.	**Content**	**COs**	**Hours**
1	**Assignment 1: Understanding Engineering Economics in Daily Life** **Aim:** To understand the importance of engineering economics in engineering and industrial decision making. **Activities:** • Discussion on meaning and scope of engineering economics • Identification of economic decisions in engineering projects • Role of economics in industry and society • Discussion on ethics and sustainability in engineering decisions	**CO1**	2
2	**Assignment2: Time Value of Money – Conceptual Study** **Aim:** To understand the concept of time value of money without calculations. **Activities:** • Explanation of money value at different times • Present value and future value using real-life examples • Conceptual understanding of simple and compound interest • Drawing a simple time line	**CO2**	2
3	**Assignment3: Cash Flow Identification and Representation** **Aim:**To identify and represent cash inflows and cash outflows **Activities:** • To identify and represent cash inflows and cash outflows. • Activities: • Identification of cash inflows and outflows in: • Small engineering project • Personal investment • Drawing simple cash flow diagrams • Interpretation of positive and negative cash flows	**CO3**	4
4	**Assignment4: Economic Comparison of Alternatives** **a) Aim: To identify different economic alternatives and compare them using simple ideas of present worth and future worth.** **Activities:** • Identification of economic alternatives → List all possible options • Understanding basic economic comparison → Compare options	**CO4**	4

	based on cost and benefit • Concept of present worth (PW) → Check value of each option at present time • Concept of future worth (FW) → Check future value/benefits of each option • Simple comparison using PW and FW → Select the best alternative		
	b) Aim: To understand comparison of alternatives based on equal and unequal life and to study deferred (delayed) investment decisions. **Activities:** • Equal life alternatives → Compare options with same life directly • Unequal life alternatives → Adjust and compare options with different life • Comparison between different life options → Choose best based on overall performance • Concept of deferred investment decision → Decide whether to invest now or later • Factors affecting decision making → Consider cost, time, risk, and future needs		4
5	**Assignment 5: Investment Decision and Project Evaluation** **a) Aim: To understand basic investment decision methods like payback period, annual worth, and rate of return.** **Activities:** • Conceptual study of payback period → Understand how long it takes to recover investment • Basic understanding of annual worth method → Understand yearly benefit or cost of a project • Concept of rate of return and IRR → Understand how much profit an investment gives (no calculation)	**CO5**	4
	b) Aim: To understand evaluation of public projects based on costs, benefits, and overall usefulness. **Activities:** • Identification of costs and benefits in public projects → List all costs and benefits • Discussion on benefit–cost analysis → Compare total benefits with total costs • Understanding sustainability → Check long-term usefulness and environmental impact.		4

6	**Assignment 6: Costing, Depreciation and Decision Making** **a) Aim:To understand different types of costs and their behavior in simple decision making.** **Activities:** • Identification of different types of costs → List various costs (material, labor, etc.) • Fixed cost examples → Identify costs that do not change (rent, salary) • Variable cost examples → Identify costs that change with production (raw material, electricity).	**CO6**	2
	b) Aim: To understand depreciation, break-even concept, and cost control methods for better decisions. **Activities:** • Meaning and importance of depreciation → Understand loss of value of assets over time • Concept of break-even point → Understand no profit, no loss situation • Cost control techniques → Identify ways to reduce unnecessary costs • Cost reduction techniques → Find methods to permanently lower costs		2

References:

Reference Books	
1	Engineering Economics by *R.Panneerselvam*, Publication: PHI Learning, 2017, ISBN: 978-9352605586
2	Engineering Economics and Costing by *M. M. Gupta*, Publication: Khanna Publishers, 2016, ISBN: 978-8121928206
3	Engineering Economics by *B. N. Datta*, Publication: Dhanpat Rai & Co., 2015, ISBN: 978-8177004929
4	Engineering Economics and Costing by *T. R. Banga & S. C. Sharma*, Publication: Khanna Publishers, 2014, ISBN: 978-8121928138
5	Cost Accounting and Financial Management by *M. N. Arora*, Publication: Vikas Publishing House, 2016, ISBN: 978-9325980389

Text Books	
1	Engineering Economics and Management by V. L. Mote, S. G. Vaidya & K. V. Bhosale Publication: Tata McGraw Hill, 2009ISBN: 978-0070087613
2	Engineering Economics by S. P. SinghPublication: Dhanpat Rai & Co., 2012ISBN: 978-8187433729
3	Engineering Economics and Costing by P. K. De & A. K. SenguptaPublication: Oxford University Press India, 2010ISBN: 978-0198065806
4	Engineering Economics and Management by K. K. ChitkaraPublication: Tata McGraw Hill, 2011 ISBN: 978-0070700239
5	Basics of Engineering Economics by R. K. RajputPublication: Laxmi Publications, 2013 ISBN: 978-8131808146

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Multidisciplinary Minor (MDM)-03 Lab				
Title of Course	**Fundamentals of Design for Product Manufacturing (FDPM) Lab**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	50	--	50	

Prerequisites: Analysis of Mechanical Elements, Material and Manufacturing Processes.

Course Objectives: The objectives of the course is to

1. To provide hands-on understanding of basic DFMA concepts using simple products.
2. To enable students to analyze and simplify product design for easy manufacturing and assembly.
3. To develop skills in identifying design inefficiencies in common engineering products.
4. To introduce basic tools for improving product quality and reducing cost.
5. To expose students to real-world applications in electronics and consumer products.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will beable to**	**Blooms Taxonomy**
CO1	Identify design issues affecting manufacturing and assembly	II
CO2	Analyze simple products for part count and assembly complexity	III
CO3	Suggest improvements for ease of manufacturing and assembly	III
CO4	Apply basic DFMA tools for product improvement	III
CO5	Evaluate simple tolerance and fit issues in products	III
CO6	Relate DFMA concepts to real-life electronics and consumer products	III

Unit No.	Content	COs	Hours
1	**Study of DFMA Principles Using a Simple Product** Select a simple product (remote, mouse, charger, etc.), Identify components and functions, Understand product structure.	**CO 1**	4
2	**Product Disassembly and Part Count Analysis** Disassemble a simple electronic/mechanical product, Count number of parts, Identify unnecessary components.	**CO 2**	4
3	**Assembly Process Study** Study assembly sequence of the product, Identify difficult assembly steps, Suggest improvements.	**CO 3**	4
4	**Material and Manufacturing Process Identification** Identify materials used in product components, Suggest suitable manufacturing processes, Compare alternatives (plastic vs metal, etc.)	**CO 4**	4
5	**Basic Tolerance and Fit Study** Observe fitting between parts, Identify loose/tight fits, Discuss impact on product performance	**CO 5**	4
6	**DFMA Tool Application (Simple Case Study)** Apply concepts like: Lean (waste reduction) Poka-Yoke (error prevention) Identify improvements in product/process.	**CO 6**	4

References:

Reference Books	
1	Product Design and Manufacturing, Avinash K. Chitale & R.C. Gupta, PHI Learning Pvt. Ltd.
2	Fundamentals of Design and Manufacturing, G.K. Lal, S. Chand Publications
3	Engineering Design & Product Development, P.S. Gill, S.K. Kataria & Sons
4	Lean Manufacturing: Tools, Techniques & How to Use Them, B. Kumar / S. Gupta, Oxford University Press
5	Design for Manufacturability – Concepts, Standards and Methods by David M. Anderson

Text Books	
1	Fundamentals of Design and Manufacturing, G.K. Lal, S. Chand Publications
2	Engineering Design & Product Development, P.S. Gill, S.K. Kataria & Sons.
3	Chitale, A. K., & Gupta, R. C., *Product Design and Manufacturing*, PHI Learning Pvt. Ltd., New Delhi.

4	Lal, G. K., *Fundamentals of Design and Manufacturing*, S. Chand Publications, New Delhi.
5	Otto, K., & Wood, K., *Product Design: Techniques in Reverse Engineering and New Product Development*, Pearson Education.

Year and Semester	Third Year B. Tech - Semester V Mechanical & Mechatronics Engineering (Additive Manufacturing)				
Course Category	Experiential Learning (EL)				
Title of Course	Minor Project 01			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25	--	25	

Prerequisite: Basic Mechanical Engg., Thermal and Fluid Engg., Single Processing, Fundamentals of Mechatronics

Course Objectives: The objectives of the course is to

1. To introduce the fundamentals of mechatronics systems and their applications.
2. To develop understanding of sensors, actuators, and control systems.
3. To provide knowledge of PLCs and microcontroller-based automation.
4. To enhance skills in system design and integration of mechanical and electronic components.
5. To develop problem-solving ability through real-life engineering applications.
6. To enable students to design, implement, and test a mini project.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Understand and explain basic concepts of mechatronics systems.	I
CO2	Select appropriate sensors and actuators for engineering applications.	II,III
CO3	Apply PLC and microcontroller concepts in automation systems.	II,III
CO4	Design and analyze simple mechatronic systems.	III,IV
CO5	Develop and implement a working prototype for a given problem.	III,V
CO6	Present project work effectively with proper documentation and analysis.	V,VI

SYLLABUS

Unit No	Content	CO	Hours
Unit 1	**Unit 1: Introduction to Mechatronics Systems**		
	• Definition and scope of Mechatronics • Elements: Mechanical, Electrical, Electronics, Control • Modern applications (automation, robotics, CNC) • System approach and interdisciplinary design • Block diagrams of mechatronic systems	**CO 1**	**04 Hrs**
Unit 2	**Unit 2: Sensors and Transducers**		
	• Types: Mechanical, Electrical, Optical sensors • Displacement, temperature, pressure sensors • Signal conditioning basics • Calibration and characteristics • Industrial sensor applications	**CO 2**	**04 Hrs**
Unit 3	**Unit 3: Actuators and Drive Systems**		
	• Electrical actuators (DC/AC motors, stepper motors) • Hydraulic and pneumatic actuators • Solenoids and smart actuators • Drive selection criteria • Industrial automation examples	**CO 3**	**04 Hrs**
Unit 4	**Unit 4: Control Systems & PLC**		
	• Open-loop and closed-loop systems • Basics of feedback control • Introduction to PLC (Programmable Logic Controller) • Ladder diagrams and programming basics • SCADA overview	**CO3, CO4**	**04 Hrs**
Unit 5	**Unit 5: Microcontrollers & Embedded Systems**		
	• Introduction to microcontrollers (e.g., 8051 / Arduino) • Interfacing sensors and actuators • Basics of embedded programming • Data acquisition systems • Applications in automation	**CO5**	**04 Hrs**
Unit 6	**Unit 6: Mini Project Development**		
	• Problem identification (industry-based) • Design methodology • Component selection • Fabrication and assembly • Testing, debugging, and result analysis • Report writing and presentation	**CO6**	**08 Hrs**

Term work: **[25 marks]**

1.	Study of Mechatronics System Components and Applications	**CO1**
2.	Study of Sensors and Transducers used in Industrial Automation Systems	**CO2**
3.	Study of Actuators and Drive Mechanisms in Mechatronic Systems	**CO3**
4.	Study of PLC-based Control Systems and Ladder Programming	**CO4**
5.	Study of Microcontroller-based Automation System (Arduino/8051)	**CO5**
6.	Design and Implementation of a Mini Mechatronics Project	**CO6**

References:

Text Books	
1	"Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", Bolton, W., Pearson Education, 7th Edition (2018).
2	"Mechatronics System Design", Shetty, D. & Kolk, R.A., Cengage Learning, 2nd Edition (2012).
3	"Introduction to Mechatronics and Measurement Systems", Alciatore, D.G.; Histand, M.B., McGraw Hill, 5th Edition (2019).
4	"Industrial Automation and Robotics", Groover, M.P., McGraw Hill, 1st Edition (1989).
5	"Programmable Logic Controllers", Petruzella, F.D., McGraw Hill, 5th Edition (2016).

Reference Books	
1	"Mechatronics: Principles and Applications", Onwubolu, G.C., Elsevier, 1st Edition (2005).
2	"Automation, Production Systems and Computer-Integrated Manufacturing", Groover, M.P., Pearson, 4th Edition (2015).
3	"Sensors and Transducers", Patranabis, D., PHI Learning, 2nd Edition (2003).
4	"Microcontrollers: Theory and Applications", Mazidi, M.A.; Mazidi, J.G.; McKinlay, R.D., Pearson, 2nd Edition (2007).
5	"Control Systems Engineering", Nise, N.S., Wiley, 7th Edition (2015).

Shivaji University, Kolhapur

T. Y. B. Tech Syllabus (as per NEP-2020)

Mechanical and mechatronics Engineering
(Additive Manufacturing)

(2026-27)

Semester VI

(Draft Copy)

SCHEME OF INSTRUCTION & SYLLABI

Programme Mechanical & Mechatronics Engineering (Additive Manufacturing)

Scheme of Instructions: First Year B.Tech. in Mechanical & Mechatronics Engineering (Additive Manufacturing)

Semester – VI

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/Wk	Course Credits	EXAM SCHEME			
									MSE	ISE/CA	ESE	TOTAL
1	PCC	MME0261	Industrial Automation Robotics	3	--	--	3	3	30	10	60	100
2	PCC	MME0262	Neural Network & Fuzzy Logic Control	3	1	--	4	4	30	10	60	100
3	PCC	MME0263	Micro & Nano Manufacturing System	3	--	--	3	3	30	10	60	100
4	PEC	MME0264	PEC - 2	3	--	--	3	3	30	10	60	100
5	PEC	MME0265	PEC - 3	3	--	--	3	3	30	10	60	100
6	MDM	MME0266	Multi-disciplinary Minor - 04	2	--	--	2	2	30	10	60	100
7	PCC	MME0267	Robot Operating System Lab	--	--	2	2	1	-	50	25	75
8	PCC	MME0268	Fabrication Lab	--	--	2	2	1	-	50	25	75
9	EL	MME0269	Minor Project 02 - Based On IAR	--	--	2	2	1	-	50	--	50
			Total	**17**	**1**	**8**	**26**	**22**	**180**	**210**	**410**	**800**

L- Lecture T-Tutorial P-Practical

MSE- Mid Semester Examination ISE/CA- In Semester Evaluation/Continuous AssessmentESE-

End Semester Examination (For Laboratory End Semester performance)

Course Category	Basic Science Courses (BSC)	Engineering Science Courses (ESC)	Programme Core Course (PCC)	Programme Elective Course (PEC)	Open Elective other than particular (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Humanities Social Science and Management (HSSM)	Experiential Learning (EL)	Co-curricular And Extracurricular Activities (CCA)
Last Sem. Cumulative Sum	**16**	**16**	**36**	**04**	**16**	**07**	**12**	**02**	**02**
Semester Credits	**-**	**-**	**12**	**06**	**02**	**--**	**-**	**01**	**-**
Cumulative Sum	**16**	**16**	**48**	**10**	**18**	**07**	**12**	**03**	**02**

PROGRESSIVE TOTAL CREDITS: 110+22 =132

Exit option : Award of B. Vocational in Major with 132 credits and an additional 8 credits fromfollowing Exit Courses				
Sr. No	**Course Code**	**Course Title**	**Mode**	**Credits**
1	ME-EC-0205	Computer Aided Drafting Lab (ANSYS, SOLIDWORKS)	Online/offline certification Course or project of total 8 credits	8
OR				
2	ME-EC-0206	Machine Maintenance Lab		8

Year and Semester	Fourth Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Programme Core Course (PCC)				
Title of Course	**Industrial Automation Robotics**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic Mechanical Engineering, Basic Electrical Engineering and Signal Processing

Course Objectives: The objectives of the course is to

1. Understand the basic concepts, need, and applications of automation in modern manufacturing systems.
2. Explain the working of industrial control systems and transfer lines used in automated production.
3. Analyze different methods and layouts of assembly automation for mass and batch production.
4. Describe the fundamentals, configuration, and applications of industrial robots.
5. Identify and select suitable robotic end effectors and sensors for industrial tasks.
6. Demonstrate basic robot teaching methods and programming techniques for industrial operations.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO I	Understand automation concepts, types, and economic aspects to design efficient systems.	II
CO II	Understand industrial control systems and transfer lines in manufacturing.	II
CO III	Understand assembly automation, including types, configurations, and product design for efficient automated assembly.	II
CO IV	Understand industrial robots, including specifications, control systems, and dynamic properties.	II
CO V	Understand robotic end effectors and sensors for efficient operation and design	II
CO VI	Understand robot teaching methods, programming languages and application.	II

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Automation**		
	Automated manufacturing systems, Fixed/programmable/flexible, Automation, Need of automation, Basic elements of automated systems- Power, program and control. Low cost automation, Economic and social aspects of automation, Advanced automation functions, Levels of automation.	**CO 1**	**07 Hrs**
Unit 2	**Industrial Control and Transfer Line**		
	a) Industrial control systems in process and discrete manufacturing industries, Continuous and discrete control; Computer process control. b) Fundamentals of transfer lines, Configurations, Transfer mechanisms, Storag ebuffers, Control, Applications	**CO 2**	**07 Hrs**
Unit 3	**Assembly Automation**		
	Assembly Automation: Types and configurations, Parts delivery at workstations, Various vibratory and non-vibratory devices for feeding and orientation, Product design for automated assembly.	**CO 3**	**07 Hrs**
Unit 4	**Fundamentals of Industrial Robots**		
	Specifications and Characteristics, Criteria for selection, Robotic Control Systems: Drives, Robot Motions, Actuators, Power transmission systems, Robot controllers, Dynamic properties of robots-stability, Control resolution, Spatial resolution, Accuracy, Repeatability, Compliance, Work cell control, Interlocks	**CO 4**	**07 Hrs**
Unit 5	**Robotic End Effectors and Sensors**		
	Transducers and sensors-Sensorsinroboticsandtheirclassification,Touch(Tactile)sensors, Proximity and range sensors, Force and torque sensing, End Effectors-Types, grippers, Various process tools as end effectors; Robot End effectors interface, Active and passive compliance, Gripper selection and design.	**CO 5**	**07 Hrs**
	Robot Teaching		
Unit 6	Introduction, Various teaching method, Task programming, Survey of Robot level programming languages, A Robot programs a Path in space, Motion interpolation, WAIT,SIGNAL and DELAY commands, Branching, Robot language structure, Various textual robot, Languages such as VALII, Typical programming examples such as palletizing, Loading a machine etc., Application of Robot.	**CO 6**	**07 Hrs**

Note - The ISE/CA is carried out through the assignment on each topic. [10 Marks]

References:

Reference Books	
1	**"Robot Technology Fundamentals",** Keramas, James G, Thomson Learning–Delmar ISBN:981- 240-621-2,(1998).
2	**"Handbook of Robotics",** Noff, Shimon Y., John Wiley and Sons.
3	**"Introduction to Robotics: Mechanics and Control",** John J. Craig, Pearson Education, 4th Edition.
4	**"Industrial Robotics: Technology, Programming and Applications",** Mikell P. Groover, McGraw Hill Education, 1st Edition.
5	**"Robotics: Modelling, Planning and Control",** Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer, 1st Edition.

Text Books	
1	**"Automation, Production Systems and Computer Integrated Manufacturing"**, Groover, M.P., Pearson Education, ISBN: 81-7808-511-9 2nd Edition (2004).
2	**"Industrial Robotics, Technology, Programming and Applications"**, Groover, M.P.; Weiss, M.; Nagel, R.N. and Odrey, N.G. , McGraw Hill Intl. Edition.,ISBN: 0-07-024989- X.
3	**"Introduction to Robotics: Mechanics and Control",** Craig, J.J., Pearson Education, 4th Edition (2018).
4	**"Robotics: Control, Sensing, Vision and Intelligence",** Fu, K.S.; Gonzalez, R.C.; Lee, C.S.G., McGraw Hill International Edition, 1st Edition (1987).
5	**"Principles of Industrial Robot Applications",** James G. Keramas, Delmar Cengage Learning, 1st Edition (1999).

Year and Semester	Fourth Year B. Tech - Semester VI Mechanical & Mechatronics Engineering-(Additive Manufacturing)				
Course Category	Programme Core Course (PCC)				
Title of Course	**Neural Networks and Fuzzy Logic Control**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	03	01	--	04	04
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisite: Basic knowledge of mathematics (linear algebra, probability), Single Processing, and programming (MATLAB/Python).

Course Objectives: The objectives of the course is to

1. Understand the fundamentals of **Artificial Intelligence techniques** applied to control systems.
2. Learn the working principles of **Artificial Neural Networks (ANN)** and **Fuzzy Logic Systems (FLS)**.
3. Design and analyze **neural network-based controllers** for dynamic systems.
4. Develop **fuzzy logic controllers** for nonlinear and uncertain systems.
5. Apply intelligent control techniques to **mechanical and mechatronic systems** such as motors, robots, and process control systems.
6. Use software tools like **MATLAB / Simulink** for modeling, simulation, and implementation

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO I	Explain the fundamentals of neural networks and fuzzy logic systems	II
CO II	Develop mathematical models of neural networks	V
CO III	Design and train ANN for control and prediction tasks	IV
CO IV	Design fuzzy inference systems and fuzzy controllers	IV
CO V	Apply intelligent control techniques to real-time engineering problems	II

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Introduction to Intelligent Control Systems** • Conventional vs Intelligent Control • Artificial Intelligence in Control • Applications in Mechanical & Mechatronics Engineering • Overview of Neural Networks and Fuzzy Logic • Hybrid Intelligent Systems	**CO1**	**07 Hrs**
Unit 2	**Artificial Neural Networks** a) Biological Neuron and Artificial Neuron b) McCulloch–Pitts Neuron Model c) Network architectures: a. Single-layer perceptron b. Multi-layer perceptron (MLP) d) Activation functions e) Learning methods: a. Supervised learning b. Unsupervised learning c. Reinforcement learning	**CO2**	**07 Hrs**
Unit 3	**Neural Network Training Algorithms** • Perceptron Learning Rule • Gradient Descent Algorithm • Backpropagation Algorithm • Convergence issues • Overfitting and generalization • Applications of ANN in control systems	**CO3**	**07 Hrs**
Unit 4	**Fuzzy Logic Systems** • Fuzzy sets and membership functions • Linguistic variables • Fuzzy operations • Fuzzy relations • Fuzzification and Defuzzification methods • Mamdani and Sugeno fuzzy inference systems	**CO4**	**07 Hrs**
Unit 5	**Fuzzy Logic Control** • Fuzzy control system architecture • Rule base design • Fuzzy PD, PI, and PID controllers • Stability and performance of fuzzy controllers • Applications in motor control, robotics, and process control	**CO5**	**07 Hrs**

	Neuro-Fuzzy and Applications		

Unit 6	• Adaptive Neuro-Fuzzy Inference System (ANFIS)
	• Neuro-fuzzy modeling
	• Intelligent control of:
	  ○ DC & AC motors
	  ○ Robotic manipulators
	  ○ Temperature and level control systems
	• Case studies
		CO 6	**07 Hrs**

Note - The ISE/CA is carried out through the assignment on each topic. [10 Marks]

References:

Reference Books	
1	**Jang, Sun & Mizutani,** Neuro-Fuzzy and Soft Computing, Pearson
2	**K. Mehrotra, C. K. Mohan,** Elements of Artificial Neural Networks, MIT Press
3	**Bose & Liang,** Neural Network Fundamentals, McGraw Hill
4	**Laurene Fausett**, Fundamentals of Neural Networks: Architectures, Algorithms and Applications, Pearson Education.
5	**H. J. Zimmermann**, Fuzzy Set Theory and Its Applications, Springer Science & Business Media.

Text Books	
1	**Timothy J. Ross**, Fuzzy Logic with Engineering Applications, Wiley
2	**Simon Haykin**, Neural Networks and Learning Machines, Pearson
3	**S. N. Sivanandam**, Introduction to Neural Networks using MATLAB, McGraw Hil
4	B. Yegnanarayana, Artificial Neural Networks, PHI Learning Private Limited, New Delhi.
5	S. Rajasekaran & G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications, PHI Learning.

Year and Semester	Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Programme Core Course (PCC)				
Title of Course	**Micro and Nano Manufacturing Systems (MNMS)**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Material and Manufacturing Processes, Additive Manufacturing

Course Objectives: The objectives of the course is to

1. To introduce the fundamentals of micro and Nano manufacturing systems and their importance in modern engineering applications.
2. To understand design considerations and scaling effects at micro and Nano dimensions.
3. To familiarize students with micro and Nano fabrication processes and manufacturing techniques.
4. To develop the ability to select appropriate materials, tools and processes for micro and Nano manufacturing.
5. To expose students to applications of micro and Nano manufacturing systems in MEMS, sensors, biomedical and advanced engineering products.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Explain the principles and challenges of micro and Nano manufacturing systems.	II
CO2	Analyze scaling laws and design constraints at micro and Nano scales.	IV
CO3	Identify and compare various micro and Nano fabrication processes.	III
CO4	Apply appropriate design methodologies for micro and Nano manufacturing systems.	IV
CO5	Evaluate applications of micro and Nano manufacturing in mechanical and mechatronic systems.	IV
CO6	Analyze real-world applications of micro and Nano manufacturing systems and evaluate design considerations, performance and industrial feasibility in mechanical and mechatronic products.	IV

SYLLABUS

Unit No	Content		Hours
Unit 1	**Introduction to Micro and Nano Manufacturing**		
	• Evolution of micro and nano manufacturing • Difference between conventional, micro and nano manufacturing • Top-down and bottom-up approaches • Scaling laws and size effects • Challenges in micro and nano system design	**CO 1**	**06 Hrs**
Unit 2	**Materials and Design Considerations at Micro and Nano Scale**		
	• Material behavior at micro and nano scale • Mechanical, thermal and electrical size effects • Surface forces and adhesion • Design constraints and tolerances in micro systems • Material selection for micro and nano manufacturing	**CO 2**	**08 Hrs**
Unit 3	**Micro Manufacturing Processes**		
	• Micro machining (micro milling, drilling, turning) • Micro forming and micro casting • Micro EDM and micro ECM • Laser-based micro machining • Applications of micro manufacturing	**CO 3**	**08 Hrs**
Unit 4	**Nano Manufacturing and Fabrication Techniques**		
	• Nanofabrication overview • Lithography techniques (Photo, electron beam, nano-imprint) • Thin film deposition techniques, Etching processes (wet and dry) • Bottom-up nano fabrication methods	**CO 4**	**08 Hrs**
Unit 5	**Design of Micro and Nano Manufacturing Systems**		
	• Design methodology for micro and nano systems • CAD tools for micro and nano design • Precision positioning and control • Metrology and inspection at micro and nano scale • Reliability and sustainability considerations	**CO 5**	**06 Hrs**

Unit 6	**Industrial Applications of MEMS and NEMS**		
	• MEMS and NEMS devices • Micro sensors and actuators • Biomedical and lab-on-chip applications • Micro and nano manufacturing in electronics and automation • Future trends and industrial challenges	**CO 6**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments on each unit. [10 Marks]

References:

Reference Books	
1	Micro and Nano Manufacturing – R. Ganesh Narayanan, PHI Learning
2	Micro Manufacturing Processes, V. K. Jain, CRC Press, 1st Edition
3	Precision Engineering and Manufacturing – Raghuwanshi & Jain, Khanna Publishers
4	Micro and Nano Manufacturing – Mark J. Jackson, Springer
5	Nano Manufacturing, Wei Gao, Elsevier, 1st Edition
6	Handbook of Nanoscience, Engineering and Technology, William A. Goddard, Donald W. Brenner, Sergei E. Lyshevski, CRC Press, 3rd Edition

Text Books	
1	Micro and Nano Manufacturing, R. Ganesh Narayanan, PHI Learning Pvt. Ltd. 1st Edition
2	Micro and Nano Manufacturing Engineering and Technology, Mark J. Jackson, Springer, 1st Edition
3	Nanomanufacturing Handbook, Mark J. Jackson, CRC Press, 1st Edition
4	Manufacturing Engineering and Technology, Serope Kalpakjian, Steven R. Schmid, Pearson Education, 7th Edition
5	Fundamentals of Microfabrication and Nanotechnology, Marc J. Madou, CRC Press, 3rd Edition

Year and Semester	Third Year B. Tech - Semester VI Mechanical & Mechatronics Engineering-Additive Manufacturing				
Course Category	Program Elective Course (PEC-2)				
Title of Course	MICRO-ELECTRO-MECHANICAL SYSTEMS (MEMS)			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisite: Basic **Mathematics, Fluid and Thermal Engineering, Basic Knowledge of Heat Transfer, Electrical Machines**

Course Objectives: The objectives of the course is to

1.Understand the concepts and context of MEMS
2 Understand various MEMS fabrication technologies
Understand MEMS-specific design issues, constraints and dynamics and modeling of
3 Microsystems
4 Understand applications of micro sensors and micro actuators
5 Getting access to fabrication and testing in academia and industry

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Understand the fundamentals of micromachining and MEMS, including IC fabrication techniques, scaling effects, and modeling approaches used in microsystems..	II
CO2	Analyze the working principles and applications of various micro-sensors (chemical, optical, pressure, thermal, magnetic) and micro-actuators (electrostatic, piezoelectric, thermal, and shape memory-based).	III
CO3	Demonstrate knowledge of micro fabrication processes such as lithography, etching (wet and dry), thin-film deposition, wafer bonding, and advanced techniques like LIGA and soft lithography..	III
CO4	Apply concepts of solid mechanics to MEMS structures, including stress-strain analysis, beam theory, residual stresses, thermal effects, and vibration analysis..	V
CO5	Evaluate thermal and fluid flow behavior in MEMS devices, including microfluidics, heat transfer in thin films, and performance of thermal sensors and actuators.	V
CO6	Understand the basics of semiconductor electronics and their integration with MEMS, along with packaging, testing, and reliability considerations of microsystems.	II

SYLLABUS

Unit No	Content	CO'S	Hours
Unit 1	**Introduction**		
	Introduction to Micromachining and MEMS, IC Fabrication, Essential technical background for lithography-based micromachining, Glimpses of Microsystems, Scaling effects, Distributed and lumped modelling approaches used in MEMS analysis and simulations	CO1	**06 Hrs**
Unit 2	**Micro sensors and Micro actuators**		
	Micro-sensors: Chemical sensors, Optical sensors, Pressure sensors, Thermal sensors – Thermopiles, Thermistors, Micro machined thermocouple probes, MEMS magnetic sensor, Micro actuators: Capacitance, Piezo mechanics, Piezo-actuators as grippers, Micro grippers, Micro motors, Micro valves, Micro pumps, Micro accelerometers, Shape memory alloy based optical switch, Thermally activated MEMS relay, Micro spring thermal actuator.	CO2	**08 Hrs**
Unit 3	**Micro fabrication Processes**		
	Structure of silicon, Silicon wafer processing, Thin-film deposition, Lithography, Wet etching and Dry etching, Process integration, Bulk micromachining and Surface micromachining, Wafer-bonding, LIGA and other moulding techniques, Soft lithography. Thick-film processing, Low temperature co-fired ceramic processing.	CO3	**07 Hrs**
Unit 4	**Mechanics of Solids**		
	Stresses and deformation: Bars and beams, Micro device suspensions: Lumped modeling, Residual stress and stress gradients, Poisson effect, Anticlastic curvature, Examples of micromechanical structures, Thermal loading: Bimorph effect, Dealing with large displacements, In-plane and 3D elasticity equations, Vibrations of bars and beams	CO4	**08 Hrs**
Unit 5	**Thermal, Fluid Flow in MEMS**		
	Thermal sensors and actuators and their analysis, Micro fluidics, Flow through micro channels, Miniature heat exchangers. Heat conduction in multi layered thin films, conduction in solids in sub micrometer scale.	CO5	**07 Hrs**
	Electronics and Packaging		
Unit 6	Semiconductor devices: Basics, Control and Microsystems, Vibration control of a beam, Integration of Microsystems and microelectronics, Packaging, Testing and reliability of Microsystems: Why and how?	CO6	**06 Hrs**

Note - The ISE/CA is carried out through any 7 Assignments from the following: [10 Marks]

1. Case study of MEMS Sensors (Pressure sensor/ Accelerometer/Gyroscope).
2. Case-study of MEMS Actuators (Micro-pump/RF switch).
3. Case-study of System on chip Drug delivery system.
4. Visit to Micro fabrication facility.
5. Visit to MEMS characterization and testing facility.
6. Lumped modelling of MEMS sensors/actuators in MAT LAB Simulink.
7. Introductory modelling of MEMS in multi physics software e.g. ANSYSCOVENT
8. Study of Electrostatic Applications in MEMS like Electrostatic actuation (parallel plate), Electro static actuation (comb drive), Electro static sensing, Piezoelectric actuation, Piezo electric sensing.
9. Study of:-

i. Gyroscopic effect, Frequency response, Damping, Quality factor, Basic micro-flows for damping calculation.

ii. Op-Amp and Op-Amp circuits, Signal conditioning for micro

1. System devices.

References:

Reference Books	
1	"Introduction to Micro electronic Fabrication", Richard C. Jaeger, Prentice Hall, 2nd Edition, Volume V,ISBN:0-201-44494-7,(2002).
2	"Nano systems: Molecular Machinery, Manufacturing and Computation", KE Drexler, Wiley, ISBN0471575186,(1992).
3	"Microsystem Design", Stephen D. Senturia, Kluwer Academic Publishers, Boston, (2001).
4	"Fundamentals of Microfabrication: The Science of Miniaturization" by Marc J Madou 2nd Edition Special Indian Edition CRC Press
5	"Micro and Smart Systems" by K. Anatha Suresh, K.J. Vinoy, S. Gopala Krishnan, et al. **Wiley india**
Text Books	
1	"MEMS and MICROSYSTEMS: Design and Manufacture", Hsu, Tai-Ran, TMH,
2	"MEMS", Mahalik, N. P., TMH, ISBN: 0-07-063445-9, (2007).
3	Foundations of MEMS (Chang Liu) 2nd Edition pearson Publication
4	"Fundamentals of Microelectromechanical Systems (MEMS)" by Eun Sok Kim Mc Graw Hill 1st Edition Indian Version
5	"An Introduction to Microelectromechanical Systems Engineering" by Nadim Maluf and Kirt Williams 2nd Edition Artech House

Year and Semester	Third Year B. Tech - Semester VI Mechanical & Mechatronics Engineering - Additive Manufacturing				
Course Category	Program Elective Course (PEC)-02				
Title of Course	**Design Of Thermal System**			Contact Hrs / Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic Knowledge of Analysis of Mechanical Elements, Fluid & Thermal Engineering, Material & Manufacturing Processes, Basic Knowledge of Heat Transfer, Basic Knowledge of CAD/CAE Tools

Course Objectives: The objectives of this course are to:

1. Learn Thermal system design methodology.
2. Understand real-life situations and be able to decide an approach for problem-solving.
3. Design simple thermal systems with advanced tools where integration of more than one component is required.

Course Outcomes:

COs	**After successful completion of this course, students will be able to:**	**Blooms Taxonomy**
CO1	Understand and apply the fundamentals of thermal system design, including design methodologies, classification, and component modeling for engineering applications.	II,III
CO2	Analyze and design refrigeration systems such as vapour compression and vapour absorption systems, including applications like household refrigerators and ice plants.	III,IV
CO3	Perform heat transfer analysis and design air conditioning systems, including load calculations, system selection, and industrial drying processes.	III,IV
CO4	Design and evaluate solar thermal systems, particularly solar-assisted water heating systems, including feasibility analysis and component design.	III,V
CO5	Develop advanced cooling solutions, including heat exchanger networks, electronic cooling systems, and applications of nano-fluids.	IV,VI
CO6	Design and conduct thermo-economic analysis of waste heat recovery systems, considering performance optimization and cost-effectiveness.	IV,V

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Introduction to Thermal System Design**		
	Classification of design, Optimal and nearly optimal design, Methodology of design, Aspects of thermal system design, Assessment concept and creation, Component modeling.	CO1	**07 Hrs**
Unit 2	**Design of Refrigeration System**		
	Design of basic components of refrigeration system, Design of refrigeration systems: vapour compression system- Household refrigerator, Ice plant, Vapour absorption systems using waste heat and solar energy.	CO2	**07 Hrs**
Unit 3	**Heat Transfer and Design Analysis of Air Conditioning System**		
	Design of Air conditioning systems: Design considerations, Load calculations, Single unit room air conditioners, Central air conditioning plant, Industrial drying systems, Component selection and Computer Aided Piping Design.	CO3	**07 Hrs**
Unit 4	**Design of Solar System**		
	Design of solar assisted water heating systems, Preliminary specifications, Concepts development, detailed design for feasibility study, Component design.	CO4	**07 Hrs**
Unit 5	**Design of Advanced Cooling Systems**		
	Design of advanced heat exchanger networks, Design of electronic miniature cooling systems, Utilization of Nano- Fluids for cooling systems.	CO5	**07 Hrs**
Unit 6	**Design and Economic Analysis of Waste Heat Recovery Systems**		
	Design of waste heat recovery systems, Design specifications, specifications and component design, Thermo Economic Evaluation and additional costing Considerations.	CO6	**07 Hrs**

Note - The ISE/CA is carried out through the Assignment on each unit. **(10 Marks)**

References:

Reference Books	
1	"Essentials of Thermal System Design", C. Balaji, CRCPress.
2	"Design of Fluid Thermal Systems", Janna W.S., Cengage Learning, 4thEdition.
3	Incropera, F.P., DeWitt, D.P., Bergman, T.L., & Lavine, A.S., Fundamentals of Heat and Mass Transfer, 7th Edition, Wiley, 2011, ISBN: 978-0470501979
4	Kakac, S., & Liu, H., Heat Exchangers: Selection, Rating, and Thermal Design, 2nd Edition, CRC Press, 2002, ISBN: 978-0849309021
5	Online Tutorials and ANSYS User Guide.

Text Books	
1	"HVAC System Design Handbook" ASHRAE.
2	"Design and Optimization of Thermal Systems", Yogesh Jalurkar, CRCPress.
3	"Design and Simulation of Thermal Systems", N.V.Suryanarayana, OnerArici,TataMcGraw
4	Suryanarayana, N.V., & Arıcı, O., Design and Simulation of Thermal Systems, Tata McGraw-Hill Education, New Delhi, 2003, ISBN: 978-0070483002
5	Dossat, R.J., & Horan, T.J., Principles of Refrigeration, 5th Edition, Pearson Education, 2001, ISBN: 978-0130272706

Year and Semester	Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective course (PEC-2)				
Title of Course	**Advanced Casting and Welding Techniques (ACW)**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisite: Analysis of Mechanical Elements, Thermal & Fluid Engineering, Material & Manufacturing Processes,

Course Objectives: The objectives of the course is to

1. Provide knowledge of advanced casting and welding processes beyond conventional manufacturing methods.
2. Explain the principles, equipment and process parameters involved in advanced casting and welding techniques.
3. Enable students to analyze defects, quality issues and metallurgical aspects of castings and welds.
4. Develop the ability to select appropriate casting or welding processes for specific materials and applications.
5. Introduce automation, simulation and recent developments in casting and welding technology.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Explain the principles and working of advanced casting and welding techniques.	II
CO2	Analyze process parameters and material behavior in advanced casting and welding operations.	IV
CO3	Identify and analyze casting and welding defects and suggest suitable preventive measures.	IV
CO4	Select appropriate casting or welding processes for given materials, geometries, and industrial applications.	III
CO5	Evaluate weld quality, metallurgical aspects, and inspection techniques in welding processes.	V

CO6	Assess recent trends, automation, and sustainability aspects in advanced casting and welding technologies.	V

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Advanced Casting Processes** Limitations of conventional casting methods. Shell molding, investment casting, lost foam casting, Permanent mold casting and squeeze casting. Advantages, limitations and applications.	**CO1**	**08Hrs**
Unit 2	**Special Casting Techniques** Centrifugal casting (true, semi and centrifuging). Continuous casting – principle and applications. Vacuum casting and slush casting.	**CO2**	**06 Hrs**
Unit 3	**Casting Defects, Quality and Simulation** Types of casting defects and their causes. Inspection and testing of castings (NDT overview). Gating and risering design concepts. Casting simulation and solidification analysis.	**CO3**	**06 Hrs**
Unit 4	**Advanced Welding Processes** Gas Tungsten Arc Welding (GTAW / TIG), Gas Metal Arc Welding (GMAW/ MIG), Plasma Arc Welding (PAW), Submerged Arc Welding (SAW) Advantages and applications	**CO4**	**08 Hrs**
Unit 5	**Special and Solid-State Welding Techniques** Resistance welding (spot, seam, projection), Friction welding and friction stir welding (FSW), Diffusion welding, Ultrasonic welding Explosive welding (principle and applications)	**CO5**	**06 Hrs**
Unit 6	**Weld Quality, Automation and Recent Trends** Weld defects and inspection methods, Residual stresses and distortion. Robotic welding and welding automation. Weldin metallurgy. Recent developments in casting and welding, Safety and sustainability aspects.	**CO3**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments/Case study on each unit. [10Marks]

References:

Reference Books	
1	R.W. Messler, Principles of Welding, Wiley
2	ASM Handbook – Casting & Welding Volume
3	A Course in Workshop Technology (Manufacturing Processes) – Volume 1 B. S. Raghuwanshi Publishe**r:** Dhanpat Rai & Co.
4	Manufacturing Engineering and Technology, S. Kalpakjian & S. R. Schmid, *Pearson*
5	Cary & Helzer, Modern Welding Technology, Pearson

Text Books	
1	Advanced Welding Technology Author: S. A. Rizvi Publisher: S. K. Kataria & Sons (India)Edition: 6th EditionYear: 2009 (latest reprint 2025)ISBN: 978-93-80027-39-5
2	Advanced Welding Techniques: Holistic View with Design Perspectives Authors: Mukti Chaturvedi, S. Arungalai Vendan Publisher: Springer Nature Singapore Year: 2021 ISBN: 978-981-33-6621-3
3	Advanced Welding Methods and EquipmentAuthors: Ruifeng Li, Taotao Li Publisher: Springer Singapore Year: 2024 ISBN: 978-981-97-4109-0
4	Advanced Welding Processes Author: J. Norrish Publisher: Woodhead Publishing / Elsevier Year: 2006 ISBN: 978-1-84569-130-1
5	Advanced Casting Technologies Editor: Thoguluva Raghavan Vijayaram Publisher: IntechOpen Year: 2018 ISBN: 978-1-78923-033-8

Year and Semester	Third Year B. Tech - Semester VI Mechanical & Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective Course (PEC)-2				
Title of Course	**Total Quality Management**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic idea of making products, checking quality, and understanding customer needs and simple problems at work.

Course Objectives: The objectives of the course is to

1. Know the concept of total quality and role of quality assurance.
2. Know planning and controlling techniques for quality
3. Know product & system reliability,
4. Know some popular approaches to TQM
5. Know TQM leadership, tools & techniques of TQM.
6. Know TQM leadership, tools & techniques of TQM

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Understand the process approach to Quality Assurance (Input Process Output).	II
CO2	Understand& apply the quality control tools to assure the product quality	III
CO3	Students will analyze the systems by using the tools like FMEA, FTA & Taguchi philosophy	III
CO4	Understand Deming's approach, Juran’s trilogy of Total Quality Management	II
CO5	Understand role of HR in TQM, 5-S & Poka Yoke techniques in TQM	II
CO6	Understand & comprehend the Quality management Systems with reference to ISO 9001:2008, QS standards	II

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Quality Assurance System**		
	• Concept of total quality, role and objectives of Q.A. • Q.A. cycle, process approach to Q.A. (input-process-output). • Input-process-output model. • Information feedback, Significance of feedback. • Q.A., Significance of internal customer approach. • Defect prevention programs for Q. A	CO1	06Hrs
Unit 2	**Planning and Controlling Techniques for Quality**		
	• Planning for quality – The dimensions of Quality (quality of Design, conformance, performance and service), Vendor control procedures. • Quality planning with vendors. • Vendor-rating. Controlling techniques for quality. • Seven statistical tools. • Process capability analysis. • Problem solving new management tools. • Why-why analysis, six sigma- Concept, Need, Implementation.	CO2	07Hrs
Unit 3	**Robust and Reliable Product Approach for Quality**		
	• Product and system reliability: Basic concepts. • Prediction and evaluation of parallel, Series and combined system reliability. • Reliability tests (life testing, burn - in test, accelerated life testing). • FMEA. • FTA. • Taguchi's quality Philosophy System design, Parameter design, Tolerance design. • Orthogonal arrays, S/N ration, Loss functions	CO3	07Hrs
Unit 4	**Principles and Approaches to TQM**		
	• Basic concepts: definition of TQM. • TQM and traditional management approach, Principles. • characteristics, and benefits of TQM. • Approaches to TQM: Deming's approach. • Juran's trilogy. • Crosby and quality improvement. • Ishikawa's CWQC.	CO4	07Hrs

Unit 5	**The Essentials of TQM** • Customer Focus, Customer perception of quality, Quality policy deployment, Quality function deployment. • Voice of customer, Customer satisfaction, Kano's model of satisfaction, Customer retention • TQM Leadership- Role and commitment and accountability of leadership, Quality policy and objectives. • Organizational structure for TQM, Role of HR in TQM. • Training for TQM, Developing quality culture. • Tools and Techniques for TQM:5-Scampaign, TEI, quality circles. • QFD, poka-yoke, KAIZEN	**CO5**	**07 Hrs**
Unit 6	**Current Trends in TQM** • TQM in service sector: Definition and meaning and service, problems in defining service quality, attributes of service quality. • SERVQUAL model, Implementing TQM in service industries. • Measurement system for service quality. • Quality Management Systems: ISO9001:2008 Series Standards–Clauses, contents. • Interpretation and implementation. • Audit Sector Specific Standards–AS9100. • ISO/ TS 16949, TL9000, Quality Awards: National and International quality awards. • Criteria and case studies.	**CO6**	**08 Hrs**

Note - The ISE/CA is carried out through six Assignments based on six units: [10 Marks]

References:

Reference Books	
1	Total Quality Management by K. Shridhara Bhat Publication: Himalaya Publishing House, 2016 ISBN: 978-9351425499.
2	Total Quality Management by Dale H. Besterfield, Carol Besterfield-Michna, Glen H. Besterfield & Mary Besterfield-Sacre Publication: Pearson Education, 2014 ISBN: 978-9332583817.
3	Total Quality Management by K. C. Arora Publication: S. K. Kataria & Sons, 2010 ISBN: 978-9350140119
4	Total Quality Management by Subburaj Ramasamy Publication: Tata McGraw Hill, 2012 ISBN: 978-0070704688
5	Total Quality Management by S. K. Sharma Publication: S. Chand Publishing, 2013 ISBN: 978-8121931847

Text Books	
1	Total Quality Management by N. V. Naidu & K. Rajendra Publication: New Age International, 2011 ISBN: 978-8122430462
2	Total Quality Management by R. S. Naagarazan Publication: New Age International, 2013 ISBN: 978-8122433814
3	Fundamentals of Total Quality Management by R. P. Mohanty & R. R. Lakhe Publication: Jaico Publishing House, 2012 ISBN: 978-8172249427
4	Total Quality Management by K. K. Chitkara Publication: Tata McGraw Hill, 2011 ISBN: 978-0070700239
5	TQM: Text and Cases by Dr. V. Jayakumar Publication: Laxmi Publications, 2014 ISBN: 978-9381159266

Year and Semester	Third Year B. Tech - Semester VI Mechanical & Mechatronics Engineering - Additive Manufacturing				
Course Category	Program Elective Course (PEC-3)				
Title of Course	Experimental Mechanics			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Analysis of Mechanical Elements, Fluid & Thermal Engineering, Material & Manufacturing Processes, Basic Knowledge of Heat Transfer.
Course Objectives: The objectives of the course is to
1. Introduce the concept of experimental stress analysis 2. Prepare mechanical engineering students for advanced graduate studies in various experimental stress analysis techniques like photo elasticity, strain gauge etc. 3. Supply qualified personnel to meet the requirement in experimental stress analysis
Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	**Explain** the principles of experimental mechanics and various methods of stress analysis along with their advantages and limitations.	II
CO2	**Apply** the concepts of two-dimensional photo elasticity including stress-optic law, fringe formation, and material calibration.	III
CO3	**Analyze** photoelastic data to determine principal stresses and directions using methods such as shear difference and oblique incidence.	IV
CO4	**Apply and evaluate** strain measurement techniques using electrical resistance strain gauges and appropriate mounting and selection criteria.	III,V
CO5	**Analyze** Wheatstone bridge circuits and strain gauge rosette configurations to determine principal stresses and strains.	IV
CO6	**Explain and compare** advanced experimental techniques such as brittle coating, birefringent coating, and moiré fringe methods for stress analysis.	II,IV

SYLLABUS

Unit No	Content	COS	Hours
Unit 1	**Principles of Experimental Approach-**		
	Introduction to Experimental Mechanics, advantages scope of Experimental Mechanics in design, various experimental methods of stress analysis and their relative merits and demerits	CO1	04 Hrs
Unit 2	**Two Dimensional Photo elasticity-**		
	Stress optics law, material fringe value in terms of stress and strain, significance of material fringe value, Nature of light, Wave theory of light – optical interference, Photo elastic Materials - Criteria for selection, common photo elastic materials and their properties, Photo elastic sheet casting and model making, calibration of photo elastic material, calibration methods using circular disc, polariscope, its scope in photo elasticity, various configurations of polariscope, effect of stressed model in plane and circular polariscope, isoclinics, isochromatics, their significance in photoelastic stress analysis Properties of 2D photoelastic model materials, Materials for 2D photoelasticity Methods for fractional fringe measurement , Tardy's method of compensation (Derivation)	CO2	12 Hrs
Unit 3	**Analysis of Photo elastic Data**		
	Principle of photoelasticity, methods of photoelastic stress analysis, temporary and permanent double refraction, Determination of direction of principal stresses at a given point, shear difference method, oblique incidence method and electrical analogy method.	CO3	06 Hrs
Unit 4	**Strain Measurement Using Strain Gauges**		
	Concept, meaning of strain gauges, desirable properties of strain gauges, types of strain gauges, Strain measurement using electrical resistance strain gauge, Selection and mounting of strain gauge, criteria for selection, mounting of gauge and checking its installation	CO4	07 Hrs
Unit 5	**Strain Gauge Circuitry**		
	Wheatstone bridge circuit, its role in measurement of resistance change, condition for bridge balance, different configurations of Wheatstone bridge, output voltage of Wheatstone bridge, relationship between output voltage and strain, commercial strain indicators, potentiometer circuit. Introduction to strain gauge rosettes, two, three and four element rosettes, different configurations of rosettes and their comparison, determination of magnitudes and direction of principal stresses when principal stress directions are specified and not specified.	CO5	07 Hrs
	Coating Methods and Moire Fringe method–		
Unit 6	Introduction, Brittle coating, coating stresses, crack patterns, crack detection techniques, selection of brittle coating, advantages, Birefringent coating:- Limitations and applications, Introduction to Birefringent coating, Birefringence coating stresses, Effects of coating thickness: Reinforcing effects, Poisson's effect , reflection polar scope	CO6	06 Hrs

	Introduction to Moiré fringe method of stress analysis – Mechanism of fringe formation, approaches to moiré fringe analysis, advantages, limitations and applications		

Note - The ISE/CA is carried out through any eight **Assignments from the following: [10 Marks]**

1. Bonding of strain gauge and checking its installation.
2. Determination of gauge factor for one arm sensitive and two arm sensitive configuration.
3. Determination of gauge factor for four arm sensitive and four arm sensitive two linear and two lateral configuration.
4. Transducer applications of strain gauge- determination of unknown weight using load cell.
5. Study of photo elastic stress analysis – use of diffused light transmission Polariscope.
6. Determination of fractional fringe order using Tardy's method.
7. Calibration of Photo elastic materials - determination of material fringe value.
8. Study of Moiré Fringe Technique.
9. Study of Brittle Coating Method.
10. Study of photo elastic materials.

Reference Books	
1	"Experimental Stress Analysis", Abdul Muben; Dhanpat Rai and Co., 1 st Edition.
2	"Principles of Experimental Stress Analysis",by American Society for Metals, 6thEdition.
3	**"Experimental Stress Analysis: Principles and Methods"** – G.S. Holister (Cambridge University Press) 1st Edition
4	. **"Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture, and Fatigue"** – *Norman E. Dowling 4th Edition*
5	**"Modern Experimental Stress Analysis"** – *James F. Doyle* (Wiley) 1st Edition
Text Books	
1	"Experimental Stress Analysis", J.W. Dally and W.F.Riley, Tata McGraw Hill Book Company, 3rdEdition
2	"Experimental Stress Analysis", Dr. Sadhu Singh; Khanna Publishers, 5 th Edition.
3	"Experimental Stress Analysis", L.S.Srinath., Tata McGrawHill.
4	"Experimental Stress Analysis", U.C. Jindal, Pearson Publications, 1 stEdition.

Year and Semester	Third Year B. Tech - Semester VI Mechanical & Mechatronics Engineering - Additive Manufacturing				
Course Category	Program Elective Course (PEC-3)				
Title of Course	CRYOGENICS			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Analysis of Mechanical Elements, Material & Manufacturing Processes, Electrical Machines, Engineering Mathematics, Basic Knowledge of Engineering Physics (Optics).

Course Objectives: The objectives of the course is to

1. Enable the students to analyze and solve cryogenics related problems by applying principles of mathematics, science and engineering.
2. Prepare students to use modern tools, techniques and skills to fulfill industrial needs related to low temperature systems.
3. Effective communication skill to demonstrate cryogenics theories.
4. Develop skills in the analysis of cryogenics systems in research or design.
5. Develop a professional approach to life long learning in the cryogenics to include the awareness of social and environment issues associated with engineering practices.

Course Outcomes:

COs	At the end of successful completion of the course, the student will be able to	Blooms Taxonomy
CO1	**Explain** the fundamentals of cryogenics, properties of cryogenic fluids, and their applications in space, medical, and industrial fields.	II
CO2	**Analyze** the behavior of structural materials at cryogenic temperatures in terms of mechanical and thermal properties.	III,IV
CO3	**Evaluate** different gas liquefaction methods and systems such as Linde-Hampson, Claude, and Cascade systems based on performance parameters.	IV,V
CO4	**Analyze and compare** liquefaction systems for gases like hydrogen and helium, and **select appropriate heat exchangers** for cryogenic applications.	IV,V
CO5	**Explain and differentiate** various cryogenic refrigeration systems such as Gifford-McMahon, Pulse Tube, and Philips systems.	II,IV
CO6	**Apply** principles of gas separation, insulation, and vacuum technology in the design of cryogenic storage and processing systems.	III,IV

SYLLABUS

Unit No	Content	CO'S	Hours
Unit 1	**Introduction:**		
	Cryogenics, Cryogenic Temperature scale, Historical Development of Cryogenics, Properties of cryogenic Fluids, Applications of cryogenics in different areas such as Space, Medical and Biological, Manufacturing processes. **Behavior of Structural Materials at Cryogenic Temperature:** Mechanical properties, Thermal properties.	CO1	04 Hrs
Unit 2	**Liquefaction of Cryogenic Gases:**		
	Ideal cycle, System performance parameters, Production of low temperature methods in Cryogenics (Joule Thomson effect, Adiabatic expansion), Liquefaction systems; Simple Linde- Hampson system, Pre-cooled Linde-Hampson system, Cascade system, Claude system, Comparison of above systems.	CO2	12 Hrs
Unit 3	**Liquefaction Systems for Neon, Hydrogen, Helium and Heat Exchanger:**		
	Maximum Inversion temperature, Limitations of Linde -Hampson System for liquefaction of Neon, Hydrogen and Helium, Precooled Linde-Hampson system for Neon and Hydrogen, Claude system for Hydrogen, Collins Helium Liquefaction system, Heat exchanger used in Liquefaction systems	CO3	06 Hrs
Unit 4	**Cryogenic Refrigeration Systems:**		
	Ideal refrigeration systems, Philips refrigerator ,Vuilleumier refrigerator, Solvay refrigerator, Gifford-McMohan refrigerator, Pulse tube refrigerator.	CO4	07 Hrs
Unit 5	**Gas Separation and Purification:**		
	Thermodynamic Ideal separation system, Temperature composition diagram, Principles of Gas separation, Principles of Rectifiers column, Air Separation Systems (Linde Single Column system, Linde double column system).	CO5	07 Hrs
	Insulation & Vacuum Technology		
Unit 6	**Insulation:** Cryogenic fluid storage, Vacuum insulation, Fibrous materials, Solid foams, Gas filled powder, Comparison. **Vacuum Technology:** Importance, Pump down time, Flow regimes, Components of vacuum systems, Mechanical Vacuum pumps, and Ion pumps	CO6	06 Hrs

Note - The ISE/CA is carried out through any six experiments/ tutorial based on above syllabus

[10 Marks]

Reference Books	
1	"Cryogenic Process Engineering",KlausD. Timmerhaus, Thomas M.Flynn,PlenumPublishing
2	"Experimental Techniques in low Temperature Physics",Guy, K White, ClaredonPress,
3	"Cryogenic Research and Applications", Marshall Sitting and Stephen Kidd, D. Van Nostrand, Inc USA,(1963).
4	"Cryogenic Research and Applications", Marshall Sitting and Stephen Kidd, D. Van
5	**Handbook of Cryogenic Engineering** – *J. G. Weisend II* (Taylor & Francis)
Text Books	
1	"Cryogenic Systems", Barron F. Randall, Oxford University Press, New York.
2	"Cryogenic Engineering", Thomas M. Flynn, Marcel Dekker. Inc, NewYork.
3	Fundamentals of cryogenic engineering – by Mamata Mukhopadhyay PHI Learning Private Limited, New Delhi
4	Cryogenics: A Textbook – S. S. Thipse, published by Narosa Book Distributors Pvt Ltd

Year and Semester	Third Year B. Tech - Semester VI Mechanical Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective Course (PEC-3)				
Title of Course	**Production Management**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequestie: Material & Manufacturing Processes, Economics for Engineers, Strategic Management

Course Objectives: The objectives of the course is to

1.Understand the basics of production management, types of production, production system & role of production manager.
2 Understand the principles of product design and factors affecting manufacturability.
3 Understand the basic concepts and techniques of material management, including MRP, inventory control methods, stores management, purchasing, and JIT & lean manufacturing,
4 Uunderstand the basic concepts and functions of Production Planning and Control (PPC) including routing, scheduling, loading, dispatching, follow-up, and basics of aggregate and capacity planning.
5, Understand the basic concepts and importance of quality management, including SQC, control charts, process capability, TQM, Six Sigma, and quality standards.
6. Understand the concepts of maintenance management and modern production trends, including automation, CIM, lean, Kaizen, agile manufacturing,.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Explain simple ideas about production types, systems, and the manager's role.	II
CO2	Explain principles of product design to improve manufacturability.	III
CO3	Apply basic inventory and material management techniques such as EOQ, ABC, and VED analysis for effective control of materials.	III
CO4	Explain and apply basic PPC activities such as routing, scheduling, loading, dispatching, follow-up, and simple aggregate and capacity planning in production systems.	III
CO5	Explain and apply basic quality management tools and concepts such as SQC, TQM, Six Sigma, and quality standards in organizations.	III
CO6	Explain and apply basic maintenance strategies and modern production practices such as automation, lean, Kaizen, agile manufacturing.	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Production Management**		
	Basics of Production Management- Definition, objectives, scope, and functions of production management Types of Production- Job production, batch production, mass production Production Systems- Continuous, intermittent, assembly line, cellular manufacturing Role of Production Manager- Responsibilities, decision-making, coordination with other functions	**CO1**	**08Hrs**
Unit 2	**Product Design and Process Planning**		
	Product design: Steps, factors affecting design, design for manufacturability Process planning: Process selection, routing, sequencing, and scheduling Work study: Method study and work measurement Time study and standard time calculations	**CO2**	**06 Hrs**
Unit 3	**Material Management**		
	Material requirement planning (MRP)Inventory control techniques: EOQ, ABC analysis, VED analysis, Stores management and purchasing, Just-in-Time (JIT) and lean manufacturing concepts	**CO3**	**08Hrs**
Unit 4	**Production Planning and Control (PPC)**		
	Objectives and importance of PPC, Routing, scheduling, and loading, Dispatching, follow-up, and production control techniques, Aggregate planning and capacity planning	**CO4**	**06Hrs**
Unit 5	**Quality Management**		
	Definition and importance of quality management, Statistical Quality Control (SQC): Control charts, process capability, Total Quality Management (TQM) and Six Sigma concepts, Quality certifications and standards (ISO, BIS)	**CO5**	**08Hrs**
Unit 6	**Maintenance and Modern Trends in Production**		
	Maintenance management: Preventive, predictive, and breakdown maintenance, Automation in production and role of computer-integrated manufacturing (CIM), Lean manufacturing, Kaizen, and agile manufacturing,	**CO6**	**06Hrs**

Note - The ISE/CA is carried out through the Assignments/Case study on each unit. [10 Marks]

References:

Reference Books	
1	"Production and Operations Management", Norman Gaither & Greg Frazier, Cengage Learning (India Edition)
2	"Production and Materials Management", K. Shridhara Bhat, Himalaya Publishing House — covers production management, materials planning, inventory, purchasing, stores, and modern production concepts.
3	"Production and Operations Management", R. Panneerselvam, Prentice Hall India — comprehensive reference for production planning, process planning, PPC, quality, and lean concepts
4	"Industrial Engineering and Production Management" – Martand Telsang
5	"Production and Operations Management" – S. N. Chary (Tata McGraw Hill)

Text Books	
1	"Production and Operations Management", Norman Gaither & Greg Frazier, Cengage Learning (India Edition)
2	"Production and Operations Management", K. C. Jain, Wiley India (Indian author).
3	"Production and Operations Management", R. B. Khanna, PHI Learning – comprehensive textbook on production management functions, planning & control, quality, maintenance, and modern manufacturing.
4	Production and Operations Management – R. Panneerselvam
5	Production and Operations Management – K. C. Jain

Year and Semester	Third Year B. Tech - Semester VI Mechanical & Mechatronics Engineering (Additive Manufacturing)				
Course Category	Program Elective Course (PEC-3)				
Title of Course	**Work study & Ergonomics**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic understanding of human work, body movements, simple tools/machines, time and effort, and awareness of safety, comfort, and efficiency in daily activities.

Course Objectives: The objectives of the course are to

1. To introduce the basic concepts and importance of work study and ergonomics in engineering.
2. To understand systematic methods for improving work processes.
3. To introduce the basic ideas of work measurement for productivity improvement.
4. To understand human capabilities and limitations in work design.
5. To apply ergonomic principles in workplace and task design.
6. To understand human–machine interaction and safety aspects in modern industry.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Students will be able to explain the importance of work study and ergonomics in engineering systems.	II
CO2	Students will be able to describe method study steps for improving work methods.	II
CO3	Students will be able to identify work measurement concepts used in industry.	III
CO4	Students will be able to explain human physical factors affecting work performance.	II
CO5	Students will be able to apply ergonomic principles to identify workplace problems.	III
CO6	Students will be able to apply ergonomic concepts to improve safety and system performance.	III

SYLLABUS

Unit No	Content	COs	Hour
Unit 1	**Introduction to Work Study & Ergonomics**		
	• Meaning and scope of work study • Objectives of productivity improvement • Meaning and importance of ergonomics • Man–machine–environment system • Role of work study and ergonomics in industry • Benefits: safety, comfort, efficiency	CO1	07Hrs
Unit 2	**Method Study**		
	• Meaning and objectives of method study Basic steps in method study • Process charts and flow diagrams (conceptual) • Work simplification • Motion economy principles (conceptual) • Practical examples from manufacturing	CO2	07Hrs
Unit 3	**Work Measurement (Conceptual)**		
	• Meaning and purpose of work measurement • Time study concept (no calculations) • Work sampling – basic idea • Standard time and performance rating (conceptual) • Allowances: relaxation, fatigue (concept only)	CO3	07Hrs
Unit 4	**Ergonomics & Work Physiology**		
	• Anthropometry: concept and importance • Static and dynamic body dimensions • Working postures: sitting and standing • Work physiology and muscular work • Fatigue: causes and prevention • Work–rest cycles (conceptual)	CO4	07Hrs
Unit 5	**Workplace Design & Manual Material Handling**		
	• Principles of workplace layout • Workstation design concepts • Manual material handling: lifting, pushing, pulling • Ergonomic tools and equipment • Musculo skeletal disorders (MSDs) • Ergonomics in machine operation.	CO5	07Hrs

	Cognitive Ergonomics, Safety & Applications		
Unit 6	• Cognitive ergonomics: perception and attention • Human errors and prevention • Human–machine interface principles • Environmental ergonomics: lighting, noise, heat • Safety and accident prevention • Ergonomics in automation and Industry 4.0	**CO6**	**07Hrs**

Note - The ISE/CA is carried out through six Assignments based on six units [10 Marks]

References:

Reference Books and Text Books	
1	Ergonomics and Human Factors by R. S. Bridger Publication: CRC Press, 2018 ISBN: 978-1498760832
2	Introduction to Work Study by I. L. Mundel & D. L. Danner Publication: Pearson Education, 2012 ISBN: 978-8120330917
3	Work Study and Ergonomics by S. Dalela & S. Sourabh Publication: Standard Publishers, 2015 ISBN: 978-8180141501.
4	Ergonomics: How to Design for Ease and Efficiency by K. H. E. Kroemer & E. Grandjean Publication: Pearson Education, 2014 ISBN: 978-9332543514.
5	Ergonomics in Industry by Umesh Prasad Publication: Sonali Publications, 2011 ISBN: 978-8184113396

Reference Books and Text Books	
1	Work Study and Ergonomics by K. K. Chitkara Publication: Tata McGraw Hill, 2010 ISBN: 978-0070700239
2	Work Study by K. B. Akhilesh Publication: PHI Learning, 2013 ISBN: 978-8120347649
3	Work Study and Ergonomics by P. C. Tewari Publication: Ane Books / Routledge India, 2017 ISBN: 978-9386761620
4	Introduction to Ergonomics by R. S. Bridger Publication: CRC Press, 2013 ISBN: 978-1439834920
5	Work Study and Ergonomics by K. C. Jain Publication: New Age International Publishers, 2019 ISBN: 978-9386649331

Year and Semester	Third Year B. Tech - Semester VI Mechanical & Mechatronics Engineering (Additive Manufacturing)				
Course Category	Multi-disciplinary Minor (MDM)-04				
Title of Course	**Ergonomics & Human Factors**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	02	--	--	02	02
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic knowledge of Ergonomics, basic understanding of human body functions, simple physics (force, work), workplace activities.

Course Objectives: The objectives of the course is to

1. To introduce the basic concepts and importance of ergonomics in engineering and daily life.
2. To understand human physical capabilities and limitations relevant to work design.
3. To introduce ergonomic principles in workplace and task design.
4. To understand human mental processes and their role in system design.
5. To study the effect of environmental factors on human performance and safety.
6. To understand practical applications and future scope of ergonomics.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Students will be able to explain the importance of ergonomics in engineering systems	II
CO2	To understand human physical capabilities and limitations relevant to work design.	II
CO3	Students will be able to identify ergonomic issues in workplace and material handling tasks.	III
CO4	Students will be able to explain human interaction with machines and systems.	II
CO5	Students will be able to identify environmental factors affecting safety and performance.	III
CO6	Students will be able to apply ergonomic concepts to real-world engineering problems	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Ergonomics & Human Factors**		
	• Meaning and definition of ergonomics and human factors • Evolution and scope of ergonomics • Man–machine–environment system • Importance of ergonomics in engineering, industry, and society • Benefits of ergonomics: safety, comfort, productivity • Applications of ergonomics in manufacturing. • Applications of ergonomics in service.	**CO1**	**05Hrs**
Unit 2	**Human Body Dimensions & Work Physiology**		
	• Anthropometry: concept and importance • Static and dynamic body dimensions • Human posture: sitting, standing, and working postures • Work physiology: basic idea of muscular work • Fatigue: causes, types, and prevention • Work–rest cycles and energy expenditure (conceptual)	**CO2**	**05Hrs**
Unit 3	**Workplace Design & Manual Material Handling**		
	• Principles of workplace layout and design • Design of workstations (conceptual) • Manual material handling: lifting, pushing, pulling • Ergonomic tools and equipment design • Prevention of musculoskeletal disorders (MSDs) • Ergonomics in machine operation	**CO3**	**05Hrs**
Unit 4	**Cognitive Ergonomics & Human–Machine Interaction**		
	• Cognitive ergonomics: meaning and importance • Human perception, attention, and memory (basic idea) • Information processing in humans • Human errors: causes and prevention • Human–machine interface (HMI) principles • Display and control design (conceptual)	**CO4**	**05Hrs**
Unit 5	**Environmental Ergonomics & Safety**		
	• Thermal comfort and heat stress • Lighting and illumination at workplace • Noise and vibration: effects and control • Workplace safety and ergonomics	**CO5**	**04Hrs**

	• Ergonomic risk factors and hazards • Accident prevention through ergonomic design		
	Ergonomics Applications, Standards & Future Trends		
Unit 6	• Ergonomics in manufacturing, healthcare, and offices • Computer ergonomics and digital workspaces • Ergonomics standards and guidelines (ISO, OSHA – overview) • Ergonomics in automation and robotics • Human factors in Industry 4.0 • Emerging trends in ergonomics	**CO6**	**04Hrs**

Note - The ISE/CA is carried out through six Assignments based on six units: (10 Marks)

References:

Reference Books	
1	Ergonomics and Human Factors by R. S. Bridger Publication: CRC Press, 2018 ISBN: 978-1498760832
2	Work Study and Ergonomics by Dr. Suresh Dalela & Saurabh Dalela Publication: Standard Publishers ISBN: 978-8180141330
3	Work Study and Ergonomics by Lakhwinder Pal Singh Publication: Cambridge University Press India ISBN: 978-1107503366
4	Essential of Ergonomics by Umesh Prasad Publication: Sonali Publications, 2011 ISBN: 978-8184113396
5	Work Study and Ergonomics by K. C. Jain Publication: New Age International Publishers ISBN: 978-9386649331

Text Books	
1	Work Study and Ergonomics by S. K. Sharma Publication: S. K. Kataria & Sons, 2003 ISBN: 978-9350144534
2	Industrial Ergonomics Publication: PHI Learning ISBN: Available online
3	Work Study & Ergonomics by S. K. Kataria & Sons Publication: Kataria Publications ISBN: Available online
4	Industrial Ergonomics by M. I. Khan Publication: PHI Learning Pvt. Ltd., 2017 ISBN: 978-8120340848
5	Industrial Ergonomics by B. S. Dhillon Publication: PHI Learning Pvt. Ltd. ISBN: 978-8120317261

Year and Semester	Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Programme Core Course (PCC) LAB				
Title of Course	**Robot Operating System Lab**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	50	25	75	

Prerequisites: Basic Mechanical Engineering, Basic Electrical Engineering and Signal Processing

Course Objectives: The objectives of the course is to

1. **Automation Basics:** Understand types and need of automation.
2. **Industrial Control:** Learn control systems and transfer line fundamentals.
3. **Assembly Automation:** Study parts feeding and assembly methods.
4. **Robot Fundamentals:** Learn robot types, motions and control systems.
5. **End Effectors & Sensors:** Understand grippers, tools and sensor types.
6. **Robot Programming:** Learn teaching methods and basic robot programming.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Identify types of automation and their applications.	II
CO2	Explain industrial control systems and transfer line operations.	II
CO3	Demonstrate assembly automation methods and parts feeding techniques.	III
CO4	Describe robot specifications, motions, and control systems.	II
CO5	Select appropriate sensors and end effectors for robotic tasks.	III
CO6	Program simple robot tasks using teaching methods and robot languages.	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Automation:**		
	Types, need, and basic elements of automated systems.	**CO 1**	**02 Hrs**
Unit 2	**Industrial Control & Transfer Lines:**		
	Control systems, transfer line configurations, and applications.	**CO 2**	**02 Hrs**
Unit 3	**Assembly Automation:**		
	Parts feeding, orientation methods, and automated assembly techniques.	**CO 3**	**02 Hrs**
Unit 4	**Fundamentals of Industrial Robots:**		
	Robot types, motions, actuators, and control systems.	**CO 4**	**02 Hrs**
Unit 5	**Robot End Effectors & Sensors:**		
	Types of grippers, tools, and sensors used in robotics	**CO 5**	**02 Hrs**
Unit 6	**Robot Teaching & Programming:**		
	Teaching methods, task programming, and basic robot languages.	**CO 6**	**02 Hrs**

Term work: **[25 marks]**

1. Study of Automation Systems: Identify and classify types of automation in manufacturing.
2. Industrial Control System Analysis: Examine continuous and discrete control systems.
3. Assembly Automation Simulation: Demonstrate parts feeding and orientation mechanisms.
4. Robot Specifications & Motion Study: Explore robot types, motions, and control characteristics.
5. End Effectors & Sensor Study: Analyze different grippers, tools, and sensors used in robots.
6. Robot Programming Exercise: Write and simulate basic robot tasks using teaching methods and commands

References:

Text Books	
1	**"Robotics and Industrial Automation**R. K. Rajput, S. Chand & Company Pvt. Ltd., Second Revised Edition.
2	**"Industrial Automatic Control and Robotics"** Chikesh Ranjan & Shahid J. Akhtar, Global Vision Publishing House, **1st Edition**.
3	**"Introduction to Robotics: Mechanics and Control",** Craig, J.J., Pearson Education, 4th Edition (2018).
4	**"Robotics: Control, Sensing, Vision and Intelligence",** Fu, K.S.; Gonzalez, R.C.; Lee, C.S.G., McGraw Hill International Edition, 1st Edition (1987).
5	**"Principles of Industrial Robot Applications",** James G. Keramas, Delmar Cengage Learning, 1st Edition (1999).

Reference Books	
1	**"Robot Technology Fundamentals",** Keramas, James G, Thomson Learning–Delmar ISBN:981- 240-621-2,(1998).
2	**"Handbook of Robotics",** Noff, Shimon Y., John Wiley and Sons.
3	**"Introduction to Robotics: Mechanics and Control",** John J. Craig, Pearson Education, 4th Edition.
4	**"Industrial Robotics: Technology, Programming and Applications",** Mikell P. Groover, McGraw Hill Education, 1st Edition.
5	**"Robotics: Modelling, Planning and Control",** Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer, 1st Edition.

Year and Semester	Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	**Programme Core Course (PCC) LAB**				
Title of Course	**Fabrication Lab**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	50	25	75	

Prerequisites: Engineering Graphics, Material and Manufacturing Processes, Workshop Practice.

Course Objectives: The objectives of the course is to

1 . To provide advanced hands-on training in fabrication processes used in mechanical and mechatronic industries.

2. To develop skills in precision manufacturing, joining, and assembly techniques.

3. To expose students to modern welding and machining practices.

4. To enable fabrication of functional components and sub-assemblies.

5. To enhance understanding of manufacturability and design-for-fabrication concepts.

6. To support prototype development for mechatronic and automation systems.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Select and safely operate advanced fabrication tools, machines, and measuring instruments.	II
CO2	Perform precision fitting, drilling, tapping, and assembly operations within specified tolerances.	II
CO3	Execute advanced welding processes (MIG/TIG/Arc) and inspect welded joints for defects.	III
CO4	Fabricate sheet metal and machined components used in mechanical and mechatronic systems.	III
CO5	Design and fabricate simple jigs, fixtures, or structural frames for engineering applications.	II
CO6	Integrate fabricated components into functional mechanical or mechatronic sub-assemblies and evaluate their performance.	III

Unit No.	Content	COs	Hours
1	**Advanced Fitting and Machining** • Precision measurement and tolerances • Drilling, tapping, reaming • Fabrication of mating components with tolerances	CO1	2
2	**Advanced Welding Techniques** • MIG / TIG welding (demonstration and practice) • Multi-pass welding • Inspection of welded joints and defect identification	CO2	4
3	**CNC Machining (Introductory)** • CNC lathe or milling machine overview • Part programming basics (G & M codes) • Fabrication of simple CNC components	CO3	4
4	**Sheet Metal Fabrication (Advanced)** • Press working operations • Bending using press brake • Fabrication of enclosures, panels, or brackets	CO4	4
5	**Jigs, Fixtures, and Assembly** • Design and fabrication of simple jigs or fixtures • Assembly of fabricated components • Alignment and fastening techniques	CO4	4
6	**Surface Finishing & Inspection** • Grinding and polishing • Surface roughness measurement • Dimensional inspection using gauges	CO2	2
7	**Fabrication for Mechatronic Applications** • Fabrication of frames for robots/automation setups • Mounts for motors, sensors, and actuators	CO5	4
8	**Mini Fabrication Project** • Design and fabrication of a mechanical or mechatronic system • Example: robotic frame, conveyor model, automated clamp, actuator mount	CO6	4

References:

Reference Books	
1	**"Course in Workshop Technology –Volume . I &II"** –B.S. Raghuwansh
2	**Production Technology – HMT Handbook**
3	**"Manufacturing Processes–II"**– HMT (Hindustan Machine Tools)
4	**"Workshop Technology –Part I & II"**–W.A.J. Chapman **Detailed theory with workshop applications.**
5	***Manufacturing Engineering and Technology – by Serope Kalpakjian & Steven Schmid**

Text Books	
1	**Manufacturing Engineering & Technology – Serope Kalpakjian**
2	**Workshop Technology – B.S. Raghuwanshi**
3	**P. N. Rao, "Manufacturing Technology", Vol. I & II.**
4	**Manufacturing Processes – P.N. Rao**
5	**Manufacturing Processes *4–5* by Lam Ngeun Virasak Publisher: Open Oregon Educational Resources Year: 2019**

Year and Semester	Third Year B. Tech - Semester VI Mechanical Mechatronics Engineering (Additive Manufacturing)				
Course Category	Experiential Learning (EL)				
Title of Course	Minor Project 02 – Based on IAR			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	50	--	50	

Prerequisites: Basic Mechanical Engineering, Industrial Automation Robotics and Signal Processing

Course Objectives: The objectives of the course is to

1. To introduce basic concepts of industrial automation robotics.
2. To help students identify simple industrial automation problems.
3. To understand the working of automation and robotic systems.
4. To explain basic control logic and sequence of operations.
5. To study the role of sensors, actuators, and controllers in automation.
6. To develop skills in technical documentation and presentation.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy**
CO1	Identify simple industrial automation or robotics problems.	I
CO2	Explain working principles of automation and robotic systems.	II
CO3	Prepare basic block diagrams and system layouts.	II
CO4	Describe control logic and sequence of operations.	II
CO5	Select suitable sensors, actuators, and controllers conceptually.	II
CO6	Present a structured technical report on automation systems.	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Problem Identification:**		
	• Selection of an industrial automation or robotics application • Objectives and expected outcomes	**CO 1**	**04 Hrs**
Unit 2	**Literature Survey:**		
	• Study of existing automation/robotic systems • Industrial relevance and applications	**CO 2**	**04 Hrs**
Unit 3	**System Description:**		
	• Block diagram of proposed system • Explanation of major components	**CO 3**	**06 Hrs**
Unit 4	**Control Logic & Operation:**		
	• Sequence of operations • Flowchart / ladder logic explanation (conceptual only)	**CO 4**	**06 Hrs**
Unit 5	**Component Selection (Conceptual):**		
	• Sensors, actuators, PLC/robot controller (no calculations) • Justification for selection	**CO 5**	**04 Hrs**
Unit 6	**Documentation & Presentation:**		
	• Project report preparation • Oral presentation and viva-voce	**CO 6**	**04 Hrs**

Term work: **[50 marks]**

1. Study of PLC-based Conveyor Automation System
2. Conceptual Design of Robotic Pick-and-Place System
3. Automation of Bottle Filling Process – System Study
4. Industrial Safety Automation using Sensors – Case Study
5. Automated Material Handling System – Conceptual Design

References:

Text Books	
1	**"Industrial Automation and Robotics" R. A. Gupta**, Laxmi Publications, Latest Edition.
2	**"Industrial Automation" S. K. Singh**, McGraw-Hill Education, Latest Edition.
3	**"Introduction to Robotics: Mechanics and Control",** Craig, J.J., Pearson Education, 4th Edition (2018).
4	**"Robotics: Control, Sensing, Vision and Intelligence",** Fu, K.S.; Gonzalez, R.C.; Lee, C.S.G., McGraw Hill International Edition, 1st Edition (1987).
5	**"Principles of Industrial Robot Applications",** James G. Keramas, Delmar Cengage Learning, 1st Edition (1999).

Reference Books	
1	**"Robot Technology Fundamentals",** Keramas, James G, Thomson Learning–Delmar ISBN:981- 240-621-2,(1998).
2	**"Handbook of Robotics",** Noff, Shimon Y., John Wiley and Sons.
3	**"Introduction to Robotics: Mechanics and Control",** John J. Craig, Pearson Education, 4th Edition.
4	**"Industrial Robotics: Technology, Programming and Applications",** Mikell P. Groover, McGraw Hill Education, 1st Edition.
5	**"Robotics: Modelling, Planning and Control",** Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer, 1st Edition.