GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013
B.E. MECHANICAL ENGINEERING
2021 batch admitted students (2018A Regulation)
PROFESSIONAL ELECTIVE COURSES: VERTICALS

Modern Mobility Systems	**Product and Process Development**	**Robotics and Automation**	**Digital and Green Manufacturing**	**Processes Equipment and Piping Design**	**Computational Engineering**
Vertical I	**Vertical II**	**Vertical III**	**Vertical IV**	**Vertical V**	**Vertical VI**
18MPE$27 Automotive materials, components, design and testing	18MPE$33 Value Engineering	18MPE$36 Principles of Robotics	18MPE$26 Automation in Manufacturing	18MPE$46 Design of Pressure Vessels	18MPE$51 Computational Solid Mechanics
18MPE$28 Conventional and futuristic vehicle technology	18MPE$17 Additive Manufacturing (Common to Mech & Prod)	18MPE$37 Robotic Drives and Control techniques	18MPE$14 Lean Manufacturing (Common to Mech & Prod)	18MPE$47 Failure Analysis and NDT Techniques	18MPE$23 Computational Fluid Dynamics
18MPE$29 Renewable powered off High Way Vehicles and Emission Control Technologies	18MPE$34 Computer Integrated Manufacturing	18MPE$38 Kinematics and Dynamics of Robotics	18MPE$42 Green manufacturing design and Practices	18MPE$48 Material processing and Solid processing equipment	18MPE$52 Theory on Computational and Visualisation
18MPE$30 Vehicle Health monitoring, Maintenance and Safety	18MPE$24 Design for Manufacture	18MPE$39 Robot Programming and Simulation	18MPE$43 Environment Sustainability and Impact assessment	18MPE$49 Rotating Machinery design	18MPE$53 Computational Bio-Mechanics
18MPE$31 CAE and CFD approach in future Mobility	18MPE$35 Ergonomics in design	18MPE$40 Robots Applications and Maintenance	18MPE$44 Energy saving Machinery and Components	18MPE$50 Thermal and Fired equipment design	18MPE$54 CAD and CAE
18MPE$32 Hybrid and Electric Vehicle Technology	18MPE$13 Process Planning and Cost Estimation (Common to Mech & Prod)	18MPE$41 Drone Technology	18MPE$45 Green Supply Chain Management	18MPE$05 Industrial Engineering	18MPE$55 Machine Learning (Common to Mech & CSE)

Vertical I: MODERN MOBILITY SYSTEMS

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18MPE$27	Automotive materials, components, design and testing	PE	40	60	100	3	0	0	3
2.	18MPE$28	Conventional and futuristic vehicle Technology	PE	40	60	100	3	0	0	3
3.	18MPE$29	Renewable powered off high way vehicles and emission control technologies	PE	40	60	100	3	0	0	3
4.	18MPE$30	Vehicle Health monitoring, Maintenance and Safety	PE	40	60	100	3	0	0	3
5.	18MPE$31	CAE and CFD approach in future Mobility	PE	40	60	100	3	0	0	3
6.	18MPE$32	Hybrid and Electric Vehicle Technology	PE	40	60	100	3	0	0	3

Vertical II: PRODUCT AND PROCESS DEVELOPMENT

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18MPE$33	Value Engineering	PE	40	60	100	3	0	0	3
2.	18MPE$17	Additive Manufacturing (Common to Mech & Prod)	PE	40	60	100	3	0	0	3
3.	18MPE$34	Computer Integrated Manufacturing	PE	40	60	100	3	0	0	3
4.	18MPE$24	Design for Manufacture	PE	40	60	100	3	0	0	3
5.	18MPE$35	Ergonomics in design	PE	40	60	100	3	0	0	3
6.	18MPE$13	Process Planning and Cost Estimation (Common to Mech & Prod)	PE	40	60	100	3	0	0	3

Vertical III: ROBOTICS AND AUTOMATION

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18MPE$36	Principles of Robotics	PE	40	60	100	3	0	0	3
2.	18MPE$37	Robotic Drives and Control techniques	PE	40	60	100	3	0	0	3
3.	18MPE$38	Kinematics and Dynamics of Robotics	PE	40	60	100	3	0	0	3
4.	18MPE$39	Robot Programming and Simulation	PE	40	60	100	3	0	0	3
5.	18MPE$40	Robots Applications and Maintenance	PE	40	60	100	3	0	0	3
6.	18MPE$41	Drone Technology	PE	40	60	100	3	0	0	3

Vertical IV: DIGITAL AND GREEN MANUFACTURING

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18MPE$26	Automation in Manufacturing	PE	40	60	100	3	0	0	3
2.	18MPE$14	Lean Manufacturing (Common to Mech & Prod)	PE	40	60	100	3	0	0	3
3.	18MPE$42	Green manufacturing Design and Practices	PE	40	60	100	3	0	0	3
4.	18MPE$43	Environment Sustainability and Impact assessment	PE	40	60	100	3	0	0	3
5.	18MPE$44	Energy Saving Machinery and Components	PE	40	60	100	3	0	0	3
6.	18MPE$45	Green Supply Chain Management	PE	40	60	100	3	0	0	3

Vertical V: PROCESSES EQUIPMENT AND PIPING DESIGN

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18MPE$46	Design of Pressure Vessels	PE	40	60	100	3	0	0	3
2.	18MPE$47	Failure Analysis and NDT Techniques	PE	40	60	100	3	0	0	3
3.	18MPE$48	Material processing and Solid processing equipment	PE	40	60	100	3	0	0	3
4.	18MPE$49	Rotating Machinery design	PE	40	60	100	3	0	0	3
5.	18MPE$50	Thermal and Fired equipment design	PE	40	60	100	3	0	0	3
6.	18MPE$05	Industrial Engineering	PE	40	60	100	3	0	0	3

Vertical VI: COMPUTATIONAL ENGINEERING

Sl. No.	Course Code	Course Title	CAT	CA Marks	End Sem Marks	Total Marks	Hours/Week			
							L	T	P	C
1.	18MPE$51	Computational Solid Mechanics	PE	40	60	100	3	0	0	3
2.	18MPE$23	Computational Fluid Dynamics	PE	40	60	100	3	0	0	3
3.	18MPE$52	Theory on Computational and Visualisation	PE	40	60	100	3	0	0	3
4.	18MPE$53	Computational Bio-Mechanics	PE	40	60	100	3	0	0	3
5.	18MPE$54	CAD and CAE	PE	40	60	100	3	0	0	3
6.	18MPE$55	Machine Learning (Common to Mech & CSE)	PE	40	60	100	3	0	0	3

VERTICAL - I

MODERN MOBILITY SYSTEMS

18MPE$27	AUTOMOTIVE MATERIALS,COMPONENTS ,DESIGN AND TESTING

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* Able to identify the components, understand the cause of problem, provide a solution to the problem and also to design and perform testing on the component.

UNIT – I : INTRODUCTION TO AUTOMOTIVE COMPONENTS	**(9 Periods)**
Automotive Components categories, Different materials used for automotive components, Functionality considerations of automotive parts, Factors influencing selection of materials for components influence of material properties on functionality and forming of components. Strengthening mechanisms and their need in automotive environment, Ferrous and nonferrous metals for automotive applications, Analysis of the relative merits and demerits of metallic materials for automotive applications. Non-metallic materials for automotive components. Thermo plastic and thermosets usage based on the functionality requirement, Ceramic materials: Need for ceramics Advantages and limitations of non-metallic materials in automotive environments.	
UNIT – II : SUSPENSION SYSTEM	**(9 Periods)**
Function, Types-conventional, independent, Spring, leaf, elliptical, semi elliptical, transverse springs. Spring camber, spring materials, Torsion bar, stabiliser bar, Shock absorbers - telescopic and gas. Maruti suspension system and shockers. Anti-bar, Nitro suspension; Testing.	
UNIT – III : STEERING SYSTEM AND FRONT AXLE	**(9 Periods)**
Principle - Ackerman and Davis, Steering gear box-types, Construction and working principal of worm and sector, rack and pinion, worm and wheel, worm and recalculating ball type, Power steering, Electronic Steering, Front axle rigid front axle, Stub axle, Tractor front axle. Wheel alignment castor angle, camber angle, Toe in and Toe out.	
UNIT – IV : BRAKING SYSTEM	**(9 Periods)**
Braking terms-braking efficiency, stopping distance, stopping time, weight transfer during braking leading/trailing shoe of brake. Determination of braking torque. Constructional details and working of mechanical, hydraulic, parking, vacuum, pneumatic and hydraulic brakes. Brakes- Drum and disc brakes, Master cylinder, tandem master cylinder and wheel cylinder, Brake lining and brake fluid, brake defects, their causes and remedies Anti-Lock Braking System (ABS) & Electronic Brake Distribution (ESC). Testing.	
UNIT – V : TRANSMISSION SYSTEM	**(9 Periods)**
Torque tube drive, Hotchkiss drive, Types - Universal joints, constant velocity joints and slip joints. Propeller shaft. Differential-slip differential, double reduction differential and final drive ratio. Tractor final drive - construction and working Rear axles-Fully floating semi-floating three quarter floating. Tractor axles; Testing.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS

1 *Karoly Jarmai –* ***''Vehicle and automotive engineering''*** *- 2017*

2 *Clemens guhmann -* ***''Simulation and testing for vehicle technology''*** *– 2016*

3 *R.K. Rajput –* ***''Textbook of automobile engineering''*** *- 2007*

REFERENCES

1 *G. Marquis. J. Solin -* ***''Fatigue design of components''*** *- 1997*

2 *Thomas D. Gillespie -****''Fundamentals of vehicle dynamics''****- 1992*

3 *Markus Maurer -* ***''Automotive systems engineering''****- 2013*

COURSE OUTCOMES

On completion of the course, the students will be able to:

CO1: Identify the different components and materials employed to manufacture them.

CO2: Able to design and test the specific suspension system based on the requirements and conditions.

CO3: Explain the working principle of steering systems and their working on different environments and their reason for failures.

CO4: Explain the working of different kind of braking system and also able to identify the causes for the occurring problem.

CO5: Able to design and check the required differentials.

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	M	-	L	H	-	-	L	M	L	-	L	M	M
CO2	M	M	M	M	L	H	-	-	L	H	M	-	L	M	M
CO3	M	M	M	M	L	H	-	-	L	M	M	-	L	M	M
CO4	M	M	M	M	L	H	-	-	L	M	M	-	L	M	M
CO5	M	M	M	H	L	M	-	-	L	H	H	-	L	M	M
18MPE$27	M	M	M	M	L	H	-	-	L	M	M	-	L	M	M
L –Low , M – Moderate(Medium), H – High															

18MPE$28	CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* Learners will understand the need for advancements in existing automotive components

UNIT – I : EVOLUTION OF VEHICLE SYSYTEMS	**(9 Periods)**
Innovations and inventions in Vehicles, Mass production, Streamlining, Development of the world motor industry, Commercial vehicles, Engine developments, Transmission system development, Steering, Suspension, Tyre's and Braking Systems.	
UNIT – II : CONVENTIONAL VEHICLE TECHNOLOGY	**(9 Periods)**
Energy Conversion, Engines - Classification of IC Engines, Application of IC Engines – Two Stroke Engines – Four Stroke Engines, Air-Standard Cycles and their Analysis - Otto Cycle - Diesel Cycle - Dual Cycle, Compression Ratio, Peak Pressure, Peak Temperature and Heat Rejection.	
UNIT – III : COMPONENTS OF CONVENTIONAL VEHICLES	**(9 Periods)**
Fuel–Air Cycles and their Analysis, Conventional Fuels, Carburetion, Mechanical Injection Systems, Electronic Injection Systems, Combustion and Combustion Chambers, Engine Friction and Lubrication, Heat Rejection and Cooling. Measurements and Testing.	
UNIT – IV : ELECTRICAL VEHICLE SYSTEMS	**(9 Periods)**
Battery Electric Vehicles - Batteries, Flywheels, Super capacitors, Electricity Supply, Electric Vehicle Modelling, Design Considerations, Heating and Cooling Systems. Design and Controlling system. Electric Vehicle Recharging and Refueling Systems.	
UNIT – V : FUTURE OF VEHICLE SYSTEMS	**(9 Periods)**
Hydrogen Engines, Dual Fuel and Multi-Fuel Engine. Computer-based combustion analysis Advanced test systems, Plug-in hybrid electric vehicles, Charging Stations for Electric Vehicles, Electric Road and Rail Systems.	

Contact Periods:

Lecture: 45 Periods **Tutorial : 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS

1 *R.K. Rajput –* ***"Textbook of automobile engineering"*** *- 2007*

2 *Julian Happian-Smith –* ***"An Introduction to Modern Vehicle Design"*** *- 2002*

REFERENCES

1 *James Larminie , John Lowry -* ***"Electric Vehicle Technology Explained"*** *- 2012*

2 *R.K. Rajput –* ***"Thermal Engineering"*** *- 2002*

COURSE OUTCOMES

On completion of the course, the students will be able to:

CO1: Know about the upgrades and revolution happened in vehicles and their systems.

CO2: Understand the working of conventional systems.

CO3: Know about systems and components used in conventional vehicles.

CO4: Reason for replacements of conventional components by electric and electronic components and the working and their efficiencies.

CO5: Get idea of ongoing as well as upcoming revolution and upgradation about to happen in vehicle systems.

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	L	L	M	-	M	M	M	-	M	H	L	L	M	M	L
CO2	L	L	H	-	M	M	M	-	M	H	L	L	M	M	L
CO3	L	L	M	-	M	M	M	-	H	M	L	L	M	M	L
CO4	L	L	H	-	M	M	M	-	L	M	L	L	M	H	L
CO5	L	L	H	-	M	M	M	-	M	H	L	M	M	H	L
18MPE$28	L	L	M	-	M	M	M	-	M	M	L	L	M	M	L
L – Low, M –Moderate (Medium), H– High															

18MPE$29	RENEWABLE POWERED OFF HIGH WAY VEHICLES AND EMISSION CONTROL TECHNOLOGIES

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

- To understand the basic features, principles, energy audit, emission and its control techniques used for reducing.

UNIT – I : INTRODUCTION TO RENEWABLE ENERGY	**(9 Periods)**
Project life cycle - Project selection and evaluation - Organizational concepts - Importance of Energy consideration in project Management - Energy Economics - Discount Rate - Payback Period - Internal Rate of Return - Life Cycle Costing.	
UNIT – II : TECHNIQUES OF RENEWABLE EVALUATION	**(9 Periods)**
Financial evaluation and RE viability - basics of engineering economics - social cost benefit analysis - technology dissemination models - dynamics of fuel substitution – fiscal - carbon financing of renewable energy - software evaluation.	
UNIT – III : ENERGY AUDIT	**(9 Periods)**
Need of energy audit - basic techniques - types of assessment - methods of rectification suggestions - economic analysis - report writing.	
UNIT – IV : CONTROL TECHNIQUES FOR REDUCTION OF EMISSION	**(9 Periods)**
Design modifications- Optimization of operating factors – Fuel modification – Evaporative emission control - Exhaust gas re circulation – DOC -SCR – Fumigation – Secondary Air injection – PCV system – Particulate Trap – CCS – Exhaust treatment in SI engines.	
UNIT – V : TEST PROCEDURE, INSTRUMENTATION & EMISSION MEASUREMENT	**(9 Periods)**
Test procedures CVS1- CVS3 – Test cycles – IDC – ECE Test cycle – FTP Test cycle - NDIR analyzer – Flame ionization detectors-Gas chromatograph – Smoke meters –SHED test.	
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**	

TEXT BOOK:

1 *S. C. Bhatia, R. K. Gupta,* ***"Renewable Energy"****, Woodhead Publishing India in Energy Series, 2019.*

2 *Robert L. Pirog, Stephen C. Stamos, Jr.,* ***"Energy Economics Theory And Policy"****, Prentice-Hall*

REFERENCES:

1 *Mehmet Kanoglu,* ***"Fundamentals and Applications of Renewable Energy",*** *1st Edition, McGraw-Hill Education, 2020.*

2 *Femina Patel,* ***"Automotive Emissions and Its Control"****, 2012.*

3 *G. Amba Prasad Rao,* ***"Engine Emission Control Technologies, Design Modifications and Pollution Mitigation Techniques"****, Apple Academic Press, 2021.*

4 *Pundir. B.P.,* ***"IC Engines Combustion and Emissions",*** *Narosa Publishers, 2010*

COURSE OUTCOMES

On completion of the course, the students will be able to:

CO1: To understand the basic features of renewable energy.

CO2: Learn the basic techniques involved in renewable evaluation.

CO3: Learn the basic principles of energy audit.

CO4: To understand the reduction of emission to environment.

CO5: To understand the test procedure and measurements in controlling the emission.

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	L	L	M	L	M	M	M	L	M	M	M	M	M
CO2	H	H	M	H	H	L	L	M	M	M	L	H	M	H	M
CO3	H	H	L	H	M	M	L	L	M	M	M	M	M	H	M
CO4	L	H	M	H	M	M	L	L	M	M	M	M	M	H	M
CO5	M	M	L	M	M	L	M	M	M	L	M	M	M	H	M
18MPE$29	M	H	L	H	M	L	L	M	M	M	M	M	M	H	M
L – Low, M –Moderate (Medium), H– High															

18MPE$30	VEHICLE HEALTH MONITORING, MAINTENANCE AND SAFETY

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To provide insight on continuous monitoring to identify the anomaly if occurred and also about maintenance of the vehicle

UNIT – I : INTRODUCTION TO WEARS IN VEHICLE SYSYTEMS	**(9 Periods)**
Wears- Engine and Its Components, Fuel, Ignition, Electrical, Exhaust, Drive Train and Transmission Systems – Suspension, Steering, Brakes, Frame and Body, Importance of maintenance, monitoring and safety systems.	
UNIT – II : MONITORING SYSTEMS	**(9 Periods)**
Database Design - Backup Systems - Command Lines, Requirement Specifications – Hardware – Software - Functional specification, Design Principles and Methodology, Context Diagram, Feasibility Analysis - Economic feasibility - Operational feasibility - Technical feasibility - Feasibility study of VTMS, Data Flow Diagrams, Screens - Master screens - Transaction screens – Reports, Testing - Testing phases - Testing methodologies - Test approach.	
UNIT – III : MAINTENANCE SYSTEMS	**(9 Periods)**
Need of Maintenance, Breakdown Maintenance – Preventive Maintenance - TPM, Service Stations Operations, Tools and Equipment. Measurement Instruments, Service and Repair of All Vehicle Systems.	
UNIT – IV : SAFETY OF VEHICLE SYSTEMS	**(9 Periods)**
Basic concepts of vehicle safety, Risk evaluation, Human error control, Risk communication, Universal design, Occupant injury prevention, Human simulation application, Crash testing, Accident reconstruction and Special design problems.	
UNIT – V : ADVANCEMENTS IN MAINTANENCE AND SAFETY SYSTEMS	**(9 Periods)**
Maintenance Planning, Fault Detection and Isolation (FDI), Predicting Maintenance - Present business solutions – FMS Systems, Methodology - Learning from historical data - Learning from real-time data streams, Future vehicle safety, Out-of-position occupants, Human interaction, Compensatory actions, The precautionary principle, Advanced features in future vehicles.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1 *George A. Peters and Barbara J. Peters* ***"Automatic Vehicle Safety"*** *- 2012*

2 *Clemens guhmann -* ***"Simulation and testing for vehicle technology"*** *– 2016*

REFERENCES:

1 *Jigar A. Doshi, Dhruv U. Panchal, Jayesh P. Maniar* ***"Vehicle maintenance and garage practice"-*** *2014*

2 *P. Raghu Vamsi* ***"Vehicle Tracking Monitoring System"***

3 *Asad Safi* ***"Vehicle Remote Health Monitoring and Prognostic Maintenance System" -*** *2017*

4 *M.Jyothi kiran, S.Ravi teja* ***"Vehicle Health Monitoring System"- 2012***

COURSE OUTCOMES

On completion of the course, the students will be able to:

CO1: Understand the causes of wears and their effects in vehicle performance

CO2: Interpret the Monitoring System and debrief their importance

CO3: Know about the maintenance system and their parameters

CO4: Know about importance of vehicle safety and their advantages

CO5: Design a newer and better safety systems as a replacement for conventional systems

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	-	-	H	M	L	L	L	M	M	L	-	M	-	L
CO2	M	-	-	M	M	M	L	L	M	M	L	-	M	-	L
CO3	M	-	-	M	M	H	M	L	M	H	L	-	M	-	L
CO4	M	-	-	M	M	H	L	L	M	M	L	-	M	-	L
CO5	M	-	-	M	M	H	L	L	M	M	L	-	M	-	L
18MPE$30	M	-	-	M	M	H	L	L	M	M	L	-	M	-	L
L – Low, M – Moderate(Medium), H – High															

18MPE$31	CAE AND CFD APPROACH IN FUTURE MOBILITY

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To familiarize and appreciate different Application of CFD and CAE in mobility industry and to impart knowledge on industrial application of CAE and different modeling methods incorporated in CFD.

UNIT – I : FUNDAMENTALS OF CAE AND CFD		**(9 Periods)**
Introduction -Basic Concepts of Finite Element Analysis-Introduction to Elasticity-Steps in Finite Element Analysis Classification , CFD- Initial and Boundary conditions, Initial and Boundary value problems. Finite difference method, Central, Forward, Backward difference		
UNIT – II	**CAE**	**(9 Periods)**
Introduction to solid modeling -Concepts of 3-D modeling-Model structure- Engineering drawing - Fundamentals of assembly and sub-assembly - Parametric modeling - Advanced feature-based design - Fundamentals of modeling for finite element analysis.		
UNIT – III	**APPLICATION OF CAE IN MOBILITY**	**(9 Periods)**
Finite element analysis (FEA)-Thermal analysis using FEA method-Kinematics and dynamics analysis in powertrain systems-Multi-physics analysis in mobility industry-Electromagnetic analysis-Structural analysis in frames and structures of automobiles.		
UNIT – IV	**CFD**	**(9 Periods)**
Classification of Partial Differential Equations and Physical Behavior-Fundamentals of Discretization and Finite Difference Method-Numerical Solutions of Navier - Stokes Equations-Numerical Grid Generation-Basics of Turbulence Modeling.		
UNIT – V	**APPLICATION OF CFD IN MOBILITY**	**(9 Periods)**
Electronic Cooling-Battery Thermal management-Power train Simulations - HVAC Analysis.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOK :

1 *S. V. Patankar,* ***"Numerical Heat Transfer and Fluid Flow"****, McGraw-Hill*

2 *Anderson J.D. (1995)* ***"Computational Fluid Dynamics: The Basics with Applications"****, McGraw-Hill Inc*

REFERENCES :

1 *Reddy. J.N.,* ***"An Introduction to the Finite Element Method"****, 3rd Edition, Tata McGraw-Hill, 2005*

2 *Chitale A.K and Gupta R.C* ***" Product design and manufacturing"*** *PHI learning private limited, 6th Edition, 2015*

3 ***"Refrigeration and Air Conditioning"*** *- C. P. Arora- Tata McGraw Hill Publication*

4 *Plett, Gregory L.* ***"Battery management systems"****, Volume I: Battery modeling. Artech House, 2015.*

COURSE OUTCOMES

On completion of the course, the students will be able to:

CO1: Understand the basic concept of FEA.

CO2: Apply principles relevant to CFD and CAE for practicality.

CO3: Analyze the working of physical problem using numerical approaches.

CO4: Understand the basic concept of finite volume method and discretization.

CO5: Evaluate the industrial view of CFD in mobility.

COURSE ARTICULATION MATRIX

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	M	M	L	M	L	M	M	L	L	L	L	L	H
CO2	L	M	M	L	L	M	L	L	L	L	L	L	L	H
CO3	L	H	H	M	M	M	L	M	L	L	L	L	L	M
CO4	L	M	M	L	L	M	M	M	L	L	L	L	L	H
CO5	L	H	M	L	M	L	L	M	L	L	L	L	L	H
18MPE$31	L	M	M	L	M	M	L	M	L	L	L	L	L	H
L – Low, M – Moderate(Medium), H – High														

18MPE$32	HYBRID AND ELECTRIC VEHICLE TECHNOLOGY

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To provide knowledge on technologies used in Hybrid and Electric vehicles.

UNIT – I : INTRODUCTION	**(9 Periods)**
Introduction to electric and hybrid electric vehicles. History of hybrid and electric vehicles. Social and environmental importance of electric and hybrid electric vehicles. Electrical basics, Motor and Generators.	
UNIT – II : ELECTRIC DRIVE COMPONENTS	**(9 Periods)**
Introduction to electric drive components used in electric and hybrid vehicles. Electric motor requirements, Direct Current (DC) motors (Brushed and Brushless), Power converters and Drive Controllers.	
UNIT – III : DRIVE TRAINS AND POWER FLOW	**(9 Periods)**
Basic concept of electric and hybrid traction, Introduction to various electric and hybrid electric drive train topologies. Power flow control in electric and hybrid electric drive train topologies, Advantages and disadvantages of different topologies.	
UNIT – IV : ENERGY STORAGE	**(9 Periods)**
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles. Battery based energy storage and its analysis. Fuel Cell based energy storage and its analysis. Super Capacitor based energy storage and its analysis. Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.	
UNIT – V : REGENERATIVE BRAKING SYSTEM	**(9 Periods)**
Introduction and need of Regenerative Braking System. Advantages and disadvantages of RBS, Working of RBS, Concept of Regenerative Braking using Piezoelectric material.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS

1 *Iqbal Hussain,* ***"Electric & Hybrid Vehicles – Design Fundamentals"****, Second Edition, CRC Press, 2021.*

2 *James Larminie,* ***"Electric Vehicle Technology Explained"****, Second edition, 2012.*

REFERENCES

1 *Chris Mi -* ***"Hybrid Electric Vehicles"*** *- 2017.*

2 *Mehrdad Eshani -* ***"Modern Electric, hybrid electric and fuel cell vehicles"*** *- 2004.*

3 *Ronald Jurgen -* ***"Electric and Hybrid-Electric Vehicles"*** *- 2002.*

4 *Gianfranco -****"Electric and hybrid vehicles"*** *- 2010*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1: Understand the importance of Electric and Hybrid vehicles
CO2: Suggest and specify the suitable motor based on the requirements
CO3: Understand the working as well as to predict the errors and failures
CO4: Select and Design a particular and suitable energy storing device
CO5: Store and utilize the energy harvested from braking system

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	M	-	M	H	M	-	L	M	M	-	L	M	L
CO2	M	L	M	-	M	-	M	-	L	M	H	-	L	M	L
CO3	M	M	L	-	M	M	M	-	L	M	H	-	L	M	L
CO4	L	H	H	H	M	-	M	-	L	M	M	-	L	M	L
CO5	M	L	M	-	M	M	M	-	L	M	H	-	L	M	L
18MPE$32	M	L	M	L	M	L	M	-	L	M	M	-	L	M	L

L – Low, M – Moderate(Medium), H– High

VERTICAL - II

PRODUCT AND PROCESS DEVELOPMENT

18MPE$33	VALUE ENGINEERING

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To apply the concepts of value engineering in the real time engineering industrial applications

UNIT – I : INTRODUCTION	**(9 Periods)**
Value engineering concepts, advantages, applications, problem recognition, and role in productivity, criteria for comparison, element of choice. Organization Level of value engineering in the organization, size and skill of VE staff, small plant, VE activity, unique and quantitative evaluation of ideas	
UNIT – II : JOB PLAN AND ANALYSIS FUNCTION	**(9 Periods)**
Introduction, orientation, information phase, speculation phase, analysis phase. Selection and Evaluation of value engineering Projects, Project selection, methods selection, application of value engineering methodology. Use esteem and exchange values, basic vs. secondary vs. unnecessary functions. Approach of function, determining function, classifying function, evaluation of costs, evaluation of worth, determining worth, evaluation of value.	
UNIT – III : VALUE ENGINEERING TECHNIQUES	**(9 Periods)**
Selecting products and operation for value engineering action, value engineering programmes, determining and evaluating function(s) assigning rupee equivalents, developing alternate means to required functions, decision making for optimum alternative, use of decision matrix, queuing theory and Monte Carlo method make or buy, measuring profits, reporting results, Follow up, Use of advanced technique like Function Analysis System.	
UNIT – IV : VERSATILITY OF VALUE ENGINEERING	**(9 Periods)**
Value engineering operation in maintenance and repair activities, value engineering in non hardware projects. Initiating a value engineering programme Introduction, training plan, career development for value engineering specialties.	
UNIT – V : VALUE ENGINEERING LEVEL OF EFFORT	**(9 Periods)**
Value engineering team, co-coordinator, designer, different services, definitions, construction management contracts, value engineering case studies.	
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**	

TEXT BOOK :

1 *Anil Kumar Mukhopadhyaya,* ***"Value Engineering: Concepts Techniques and applications"****, SAGE Publications 2010*

2 *Khanna, O.P.,* ***"Industrial Engineering and Management"****, Dhanpat Rai & Sons, 1993*

REFERENCES :

1 *Alphonse Dell'Isola,* ***"Value Engineering: Practical Applications for Design, Construction, Maintenance & Operations"****, R S Means Co., 1997*

2 *Richard Park,* ***"Value Engineering: A Plan for Invention"****, St. Lucie Press, 1999*

3 *Del L. Younker,* ***"Value Engineering analysis and methodology"****, Marcel Dekker Inc, New York, 2004*

4 *Miles, L.D.,* ***"Techniques of Value Analysis and Engineering"****, McGraw Hill second Edition, 1989*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1: Understand the concepts of value engineering, identify the advantages, applications

CO2: Analysis various phases of value engineering. Analyze the function, approach of function and evaluation of function. Determine the worth and value.

CO3: Implement the concept of queuing theory

CO4: Appraise the value engineering operation in maintenance and repair activities

CO5: Create the value engineering team and discuss the value engineering case studies

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	M	H	M	H	M	M	L	L	M	M	L	M	L
CO2	H	M	H	H	M	M	M	M	L	L	H	L	M	M	M
CO3	M	M	M	M	M	M	M	L	L	L	M	L	M	M	M
CO4	M	M	M	H	L	L	M	L	L	M	L	L	L	L	M
CO5	M	M	M	H	M	M	L	M	H	L	L	H	M	H	M
18MPE$33	M	M	M	H	M	L	M	M	L	L	M	M	M	M	M

L – Low, M – Moderate(Medium), H– High

18MPE$17	**ADDITIVE MANUFACTURING** *(Common to MECH & PROD Branches)*

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

* To educate students with fundamental and advanced knowledge in the field of Additive Manufacturing technology and the associated Aerospace, Architecture, Art, Medical and Industrial applications.

UNIT – I : INTRODUCTION	**(9 Periods)**
Need - Development of AM systems – AM process chain - Impact of AM on Product Development - Virtual Prototyping- Rapid Tooling – RP to AM - Classification of AM processes – Benefits – Applications. Software for AM- Case studies.	
UNIT – II: REVERSE ENGINEERING AND CAD MODELING	**(9 Periods)**
Basic concept- Digitization techniques – Model reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data requirements – Geometric modeling techniques: Wireframe, surface and solid modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation.	
UNIT–III: LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS	**(9 Periods)**
Stereo lithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and application. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications.	
UNIT- IV : POWDER BASED ADDITIVE MANUFACTURING SYSTEMS	**(9 Periods)**
Selective Laser Sintering (SLS): Principle, process, indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications – case Studies, Selective Laser Melting and Electron Beam Melting	
UNIT–V : OTHER ADDITIVE MANUFACTURING SYSTEMS	**(9 Periods)**
Three dimensional Printing (3DP): Principle, basic process, Physics of 3DP, types of printing, process capabilities, material system. Solid based, Liquid based and powder based 3DP systems, Demerits, Applications and case studies. Shape Deposition Manufacturing (SDM), Ballastic Particle Manufacturing (BPM), Bio Additive Manufacturing.	

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Chua Chee Kai and Leong Kah Fai.,* ***"Rapid Prototyping: Principles and Applications in Manufacturing",*** *John Wiley AND Sons, 1997*
2. *Paul F. Jacobs,* ***"Stereo-lithography and other RP & M Technologies"****, from Rapid Prototyping to Rapid Tooling, SME/ASME,1996*

REFERENCE BOOKS:

1. *Gibson, I., Rosen, D.W. and Stucker, B,* ***"Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing",*** *Springer, 2010.*
2. *Chua, C.K., Leong K.F. and Lim C.S.,* ***"Rapid prototyping: Principles and applications",*** *second edition, World Scientific Publishers, 2010.*
3. *Gebhardt, A.,,* ***"Rapid prototyping",*** *Hanser Gardener Publications, 2003*
4. *Liou, L.W. and Liou, F.W,* ***"Rapid Prototyping and Engineering applications: A tool box for prototype development"*** *CRC Press, 2011*
5. *Hilton, P.D. and Jacobs, P.F,* ***"Rapid Prototyping and Engineering applications: A tool box for prototype development",*** *CRC press, 2005*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1: Appreciate the importance of computers and modern tools in manufacturing to reduce cost and matching the societal needs.

CO2: Create and analyze 2D and 3D models using CAD modeling software and integrating with manufacturing systems.

CO3: Understand the variety of Additive Manufacturing (AM) technologies apply to their potential to support design and manufacturing, case studies relevant to mass customized manufacturing.

CO4: Apply knowledge on latest techniques of manufacturing in their field of career

CO5: To monitor and control shop floor with the aid of computers.

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	-	-	L	-	-	-	M	-	-	-	-	-	L	L	-
CO2	-	-	M	-	-	-	-	-	-	-	-	-	-	M	L
CO3	-	-	L	-	-	-	-	-	-	-	-	-	M	L	-
CO4	-	-	M	-	H	M	L	-	-	-	-	-	M	H	L
CO5	-	M	-	-	-	L	-	-	-	-	M	-	L	H	-
18MPE$17	-	M	M	-	M	L	L	-	-	-	L	-	M	M	L

L – Low, M – Moderate(Medium), H– High

18MPE$34	COMPUTER INTEGRATED MANUFACTURING

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To create knowledge on manufacturing activities, CNC, Group Technology, data communications and open system with computers for plant operations.

UNIT - I : INTRODUCTION TO CIM	**(9 Periods)**
Meaning and origin of CIM-Changing manufacturing and management scene-meaning of integrated-Islands of automation and software – elements of CIM- Computing system-computer software: operating systems-CAD and design-CAD systems and modellers-computer aided engineering and software tools.	
UNIT – II : NUMERICAL CONTROL TECHNOLOGY	**(9 Periods)**
Fundamentals of NC Technology -Basic Components of an NC System-NC Coordinate Systems-Motion Control Systems-Computers and Numerical Control-The CNC Machine Control Unit-CNC Software-Distributed Numerical Control-Applications of NC-Machine Tool -Analysis of Positioning Systems-Open-Loop Positioning Systems-Closed-Loop Positioning Systems-Precision in Positioning Systems.	
UNIT - III : SHOP FLOOR CONTROL AND FMS	**(9 Periods)**
Shop floor control-phases - factory data collection system - automatic identification methods Bar code technology-automated data collection system. FMS- types - FMS workstation -material handling and storage systems FMS layout -computer control systems-application and benefits.	
UNIT - IV : DATA COMMUNICATION AND IMPLEMENTATION	**(9 Periods)**
Communication fundamentals- local area networks -topology - LAN implementations – network management and installations. CIM and company strategy - system modeling tools -IDEF models - activity cycle diagram - CIM open system architecture (CIMOSA)- manufacturing enterprise wheel-CIM architecture - Product data management-CIM implementation software.	
UNIT - V : OPEN SYSTEM AND DATABASE FOR CIM	**(9 Periods)**
Open systems-open system inter connection - manufacturing automation protocol and technical office protocol (MAP /TOP). Database terminology- architecture of database systems-data modeling and data associations -relational data bases - database operators - advantages of data base and relational database.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Mikell P. Groover,* ***"Automation, Production Systems, and Computer-integrated Manufacturing",*** *Pearson Education,2018.*
2. *Roger Hanman,* ***"Computer Integrated Manufacturing: From concepts to realisation"****, Addison –Wesley,1998*
3. *Radhakrishnan P, Subramanyan S.and Raju V.,* ***"CAD/CAM/CIM",*** *3rd Edition, New Age International (P) Ltd, New Delhi, 2009.*

REFERENCE BOOKS:

1. *Kant Vajpayee S,* ***"Principles of Computer Integrated Manufacturing",*** *Prentice Hall India, 2007.*
2. *Gideon Halevi and Roland Weill,* ***"Principles of Process Planning – A Logical Approach"*** *Chapman & Hall, London, 1995.*
3. *P Rao, N Tewari and T.K. Kundra,* ***"Computer Aided Manufacturing",*** *Tata McGraw Hill, 2000.*
4. *Groover Mikell. P.and Emory Zimmers Jr.,****"CAD/CAM"- Computer Aided Design and Manufacturing",*** *Pearson, 2008.*
5. *Peter Scallan,* ***" Process Planning: The design/manufacture interface,"*** *Elsevier Science & Technology Books.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Get a comprehensive picture of computer assisted manufacturing operations
CO2: Familiarize the basic of CNC systems
CO3: Identify the data collection system and FMS
CO4: Select the network system for data communication
CO5: Identify the suitable open system and data base for computer integrated manufacturing

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	L	-	M	-	M	-	-	-	-	-	-	L	-	M	L
CO2	L	-	M	-	M	-	-	-	-	-	-	L	-	M	L
CO3	L	-	H	-	M	-	-	-	-	-	-	L	-	M	L
CO4	L	-	H	-	M	-	-	-	-	-	-	L	-	M	L
CO5	L	-	H	-	M	-	-	-	-	-	-	L	-	M	L
18MPE$34	L	-	H	-	M	-	-	-	-	-	-	L	-	M	L

L – Low, M – Moderate(Medium), H– High

18MPE$24	DESIGN FOR MANUFACTURE

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

- Manufacturing Technology I
- Manufacturing Technology II

COURSE OBJECTIVES:

* To create knowledge about the design factors which are influencing the manufacturing process
* To select proper manufacturing process with the environment concerns.

UNIT – I : DESIGN PRINCIPLESFOR MANUFACTURABILITY	**(9 Periods)**
General design principles for manufacturability – Mechanical properties of material: Tensile properties, Engineering stress-strain, True stress strain, Compression properties, Shear properties, mechanisms selection, evaluation method, process capability – feature tolerances –geometric tolerances – assembly limits –datum features – tolerance stacks.	
UNIT – II : FACTORS INFLUENCING FORM DESIGN	**(9 Periods)**
Working principle, material, manufacture, design- possible solutions - materials choice - influence of materials on form design - form design of welded members, forgings and castings.	
UNIT – III : MACHINING COMPONENT DESIGN	**(9 Periods)**
Design features to facilitate machining - drills - milling cutters - keyways - reduction of machined area-simplification by separation - simplification by amalgamation - design for machinability - design for economy - design for clampability - design for accessibility - design for assembly. Recommended materials for machinability, Design recommendations - Design for machining round holes: Introduction, Suitable materials, Design recommendations, Recommended tolerances.	
UNIT – IV : CASTING COMPONENT DESIGN	**(9 Periods)**
Redesign of castings based on parting line considerations - minimizing core requirements, machined holes, redesign of cast members to obviate cores. Identification of uneconomical design - modifying the design - group technology. Die casting: Introduction to die casting, Applications, Suitable material consideration, General design consideration, Specific design recommendation, Design for powder metal processing: Introduction to powder metal processing, Typical characteristics and applications, Design recommendations.	
UNIT – V : DESIGN FOR ENVIRONMENT	**(9 Periods)**
Introduction – environmental objectives – global issues – regional and local issues – basic DFE methods – design guidelines – lifecycle assessment method – techniques to reduce environmental impact –design for energy efficiency – design to regulations and standards.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

*1. Robert Matousek, **"Engineering Design- A systematic approach"**, Blackie &sons ltd., 1963*

*2. Harry Peck, **"Design for Manufacture"**, Pitman Publishers, 1983.*

REFERENCE BOOKS:

1. *Boothroyd, G, **"Design for Assembly Automation and Product Design"**, New York, Marcel Dekker. 1980*
2. *Bralla, **"Design for Manufacture handbook"**, McGraw hill, 1999.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1: Analyse the design principles for manufacturiability
CO2: Selection of methods for productivity with considerations of factors
CO3: Analyse the design considerations for machining the components
CO4: Selection of component design for casting
CO5: Selection of materials for the design of experiments

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	H	M	H	M	M	M	M	M	H	H	H	M
CO2	H	H	H	H	M	H	H	H	H	H	H	H	L	L	M
CO3	H	H	H	M	M	H	H	H	H	H	H	H	L	L	M
CO4	H	H	H	H	H	M	H	H	H	H	H	H	L	L	M
CO5	H	H	H	H	M	M	L	L	M	H	H	H	H	H	H
18MPE$24	H	H	H	H	M	H	M	M	H	H	H	H	M	M	M

L – Low, M – Moderate(Medium), H– High

18MPE$35	ERGONOMICS IN DESIGN

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Provide a broad based introduction to ergonomic principles and their application in the design of work, equipment and the workplace.

UNIT – I : OVERVIEW OF ERGONOMICS	**(9 Periods)**
General Principles -Aims, objectives and benefits of ergonomics -Definition and scope of ergonomics - The role of the ergonomist -Human characteristics, capabilities and limitations - Human error -Interfaces between job, person and environment . Biological Ergonomics Body systems - musculo-skeletal and nervous -Anatomy, static and dynamic anthropometry - Applying work physiology - body metabolism, work capacity and fatigue - Static and dynamic postures - Psychology - Signal Detection Theory and vigilance - 'Work 'Stress' - causes, preventative and protective measures -Developing an Ergonomics Strategy at Work -Developing ergonomics, professional ergonomists and competence	
UNIT – II : ERGONOMICS METHODS & TECHNIQUES	**(9 Periods)**
Work Design-Task analysis and allocation of functions-Problem solving - scientific method Ergonomics Risk Assessment-Risk evaluation quantity and quality of risk - Assessment systems - Overall ergonomics approach-Ergonomics standards -Observational techniques - Rating scales, questionnaires and check lists	
UNIT – III : MUSCULO-SKELETAL DISORDERS	**(9 Periods)**
Manual Handling - The nature and causes of manual handling disorders - Risk assessment - Job design and training - Principles of handling and preventative and protective measures - Work Related Upper Limb Disorders (WRULD) - The nature and causes of WRULD/ 'Repetitive Strain Injuries'/Cumulative Disorders - Risk assessment - Principles of control, preventive and protective measures	
UNIT – IV : WORKPLACE, JOB AND PRODUCT DESIGN	**(9 Periods)**
Workplace Layout and Equipment Design - Principles of workstation and system design - Space and workstation design principles - Risks to health-Design considerations for Visual Display Unit (VDU) Stations: Ergonomic factors , Work stations , Design of work and practice-Controls, Displays and Information - Visual, auditory and other displays - Quantitative and qualitative information - Compatibility and population stereotypes - Warnings, signs and labels	
UNIT – V : RELEVANT PHYSICAL FACTORS OF THE WORK ENVIRONMENT, STANDARDS AND SOCIAL ASPECTS	**(9 Periods)**
Lighting-Noise-Thermal environment-smell, tactile senses-Vibration-Clothing and protective equipment Standards - ISO standards -Sources of other standards - Selection and Training - Health information, legal requirements - Measuring health and illness	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1.Stephen Konz and Steve Johnson, ***"Work Design: Occupational Ergonomics 7th Edition"****, Holcomb Hathway,2007*

2. R.S.Bridger ***"Introduction to Ergonomics"****, Taylor & Francis,2003*

REFERENCE BOOKS:

1. *WHO in collaboration with IEA,* ***"Ergonomic checkpoints: Practical and easy to- implement solutions for improving safety, health and working conditions. Second edition"****,WHO, 2010*
2. *Chitale A.K and Gupta R.C* ***The Ergonomics of Workspaces & MachinesTaylor & Francis,1995***
3. *Dul & Weerdmeester* ***"Ergonomics for Beginners" - Taylor & Francis,2003***
4. *Pheasant & Haslegrave****. "Bodyspace: Anthropometry Ergonomics and Design", Taylor & Francis,2006***

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1: Apply ergonomic principles to the creation of safer, healthier and more efficient and effective activities in the workplace;

CO2: Conduct ergonomic risk assessments & develop appropriate control measures for ergonomic risk factors

CO3: Describe work-related causes of musculo-skeletal disorders

CO4: Design a workplace according to good ergonomic principles

CO5: Assess ergonomic aspects of the working environment and work organization

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	M	M	L	H	H	M	L	M	M	M	L	H	H
CO2	H	H	H	M	H	H	L	H	L	L	L	M	L	H	H
CO3	H	M	L	L	L	H	H	M	H	H	L	M	L	M	H
CO4	H	M	M	M	L	M	H	M	L	M	M	M	L	H	H
CO5	H	M	M	L	L	M	H	H	L	L	M	M	L	H	H
18MPE$35	H	M	M	M	L	H	H	M	L	M	M	M	L	H	H

L – Low, M – Moderate(Medium), H– High

18MPE$13	PROCESS PLANNING AND COST ESTIMATION *(Common to MECH & PROD Branches)*

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

- Manufacturing Technology I
- Manufacturing Technology II

COURSE OBJECTIVES:

* To give an understanding of the fundamentals of Process Planning and estimation of appropriate costs of processes and products and applying these to manage competitive manufacturing systems and organizations

UNIT – I: PROCESS PLANNING	**(9 Periods)**
Introduction of Process Planning- Aims and Objectives- material evaluation methods of process planning, steps in process selection, production equipment and tooling selection Place of process planning in Manufacturing cycle, Drawing interpretation, Dimensional tolerance vs Production processes	
UNIT – II : PROCESS PLANNING STEPS	**(9 Periods)**
Design of a process plan – Selection of production processes, tools and process parameters- Positioning and work holding devices, selection of jigs and fixtures, selection of quality assurance methods, Selection of inspection devices and tools, Documenting the process plan, Simple Case studies. Computer-Aided Process Planning (CAPP) – Benefits, Architecture and approaches.	
UNIT – III : COST ESTIMATION	**(9 Periods)**
Importance, Types, Purpose, Components, Procedure, Classification of costs, Cost elements, Overhead expenses, Break-even analysis, types of estimates, estimating procedure, estimation of labor cost, material cost, allocation of overhead charges, calculation of depreciation cost.	
UNIT – IV : PRODUCTION COST ESTIMATION	**(9 Periods)**
Estimation of production cost for - Casting processes, Welding processes, and Forging processes, different production processes for different jobs, estimation of forging cost, estimation of welding cost, estimation of foundry cost, estimation of machining cost.	
UNIT – V : ESTIMATION OF MACHINING TIME AND COST	**(9 Periods)**
Importance of machine time calculation, machining time for different lathe operations, drilling and boring time calculations, Machining time calculation for Milling, Shaping, Planing and Grinding, Cost estimation for machining processes.	

Contact Periods:

Lecture: 45 Periods Tutorial:0 Periods Practical:0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Gideon Halevi,* ***"Process and Operation Planning",*** *Kluwer academic publishers (Printed ebook), 2003*
2. *M. Adithan,* ***"Process Planning and Cost Estimation",*** *New Age International Publishers, 2007*
3. *T.R.Banga and S.C.Sharma,* ***"Estimations and Costing",*** *Khanna Publishers,1988*

REFERENCE BOOKS:

1. *Peter Scalon,* ***"Process Planning, Design/ Manufacture Interface",*** *Elsevier Sci.&Tech. 2002.*
2. *Ostwaal P.F. and Munez J.,* ***"Manufacturing Processes and Systems",*** *9th ed., John Wiley*
3. *Chitale A.V. and Gupta R.C.,* ***"Product Design and Manufacturing",*** *2nd ed., Prentice Hall*
4. *Robert Creese, M. Adithan, B.S Pabla,* ***"Estimating and Costing for the Metal Manufacturing Industries",*** *Marcel Dekker, 1992.*
5. *G.B.S. Narang, V. Kumar,* ***"Production and Costing",*** *Khanna Publishers, 2000*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Select logical, rational and economical process plans, equipment and tools.
CO2: Estimate process planning steps and select work holding devices
CO3: Estimate cost of Components and Products**.**
CO4: Estimate production cost of various manufacturing processes
CO5: Estimate Machining time and cost of various machining processes

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	M	M	H	H	L	M	M	M	H	H	M	M	M
CO2	H	H	M	H	H	L	L	M	M	M	L	H	M	H	M
CO3	H	H	M	H	M	H	M	M	M	M	M	M	M	H	M
CO4	H	H	M	H	M	M	M	L	M	M	M	M	M	H	M
CO5	H	M	M	M	M	M	M	M	M	L	M	M	M	H	M
18MPE$13	H	H	L	M	H	M	H	H	M	H	M	M	M	M	M

L-Low, M-Moderate(Medium), H-High

VERTICAL - III

ROBOTICS AND AUTOMATION

18MPE$36	PRINCIPLES OF ROBOTICS

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To impart knowledge on the functional elements of robotics, robot motion analysis, cell design and applications of robotics.

UNIT – I: INTRODUCTION OF ROBOTS	**(9 Periods)**
Progressive advancement in robots –First generation, Second generation, Third generation, Fourth generation - Laws of robotics – Robot structure - work envelope – classification - joint notations, types of joints - robot parts and their functions – specifications - speed of motion - pay load - precision of movement - Need for robots in Indian scenario - A view on Global and Indian manufacturers of Robots. Capabilities of robotics.	
UNIT – II: ROBOT AND ITS PERIPHERALS	**(9 Periods)**
End effectors – Types of end effectors - control systems and components - basic control systems concepts and models – controllers - control system analysis - robot sensors and actuators - velocity sensors – actuators - power transmissions systems - modeling and control of a single joint robot.	
UNIT – III: ROBOT MOTION ANALYSIS AND CONTROL	**(9 Periods)**
Introduction to manipulator kinematics - homogeneous transformations - inverting a homogeneous transformations – fundamental rotation matrix - manipulator path control - motion types - joint space - world space technique- configuration of robot controller.	
UNIT – IV: ROBOT CELL DESIGN AND CONTROL	**(9 Periods)**
Robot cell layouts - multiple robots and machine interference - other considerations in workcell design - workcell control – interlocks - error detection and recovery - workcell controller - robot cycle time analysis.	
UNIT – V: ADVANCES IN ROBOTICS AND APPLICATIONS	**(9 Periods)**
Artificial Intelligence and robotics - flexible automation – robot vision systems - obstacle avoidance - feasibility of robotization plan – planning for robot initialization - the future of robotics - Applications of robots: material transfer, machine loading and unloading, assembly and inspection.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *M.P.Groover, M.Weiss, R.N. Nageland N. Godrej,* ***"Industrial Robotics"****, McGraw-Hill Singapore, 2017.*
2. *K.Mittal and I.J.Nagrath,* ***"Robotics and Control",*** *Tata McGraw Hill, New Delhi, 2017.*

REFERENCE BOOKS:

1. *Ashitava Ghoshal,* ***"Robotics-Fundamental Concepts and Analysis",*** *Oxford University Press, Sixth impression, 2010.*
2. *K. K.Appu Kuttan,* ***"Robotics"****, I K International, 2007.*
3. *Edwin Wise,* ***"Applied Robotics",*** *Cengage Learning, 2003*
4. *Y. S. Nof, "****Handbook of Industrial Robotics"*** *2nd Edition, John Wiley, 2013.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Select the robot for the various industrial applications

CO2: Analyse the role of the actuators and sensors in manufacturing system.

CO3: Evaluate the manipulator motion of a robot.

CO4: Design and control the robot cell for industrial applications.

CO5: Implement the recent techniques of artificial intelligence in robotics applications.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	H	M	M	M	M	-	-	-	M	M	M	M	M
CO2	M	M	H	M	M	M	M	-	-	-	M	M	M	M	M
CO3	M	M	H	M	M	M	M	-	-	-	M	M	M	M	M
CO4	M	M	H	M	M	M	M	-	-	-	M	M	M	M	M
CO5	M	M	H	M	M	M	M	-	-	-	M	M	M	M	M
18MPE$36	M	M	H	M	M	M	M	-	-	-	M	M	M	M	M
L-Low, M-Moderate (Medium), H-High															

18MPE$37	ROBOTIC DRIVES AND CONTROL TECHNIQUES

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To familiarize students with the concepts and techniques of robot drive systems to select and choose correct one to incorporate robots and to be able to control the robotic system with suitable methods.

UNIT – I: ROBOTICS AND SENSORS	**(9 Periods)**
Introduction about robot - robot anatomy - Types of motions obtained from robot - joint notations - types of joints - work envelope - Drives used to operate the robot - Need for sensing systems – principles, types and applications of sensors – Proximity sensor (Inductive, Hall effect, Capacitive, Ultrasonic and Optical) – Range sensor (Triangulation, Structured light approach) – Speed and Position sensor (resolvers, optical encoders) – Force sensor– Torque sensor – Touch sensor (binary, analog).- IR sensor – Temperature sensor - Choosing the right sensors for robotic applications.	
UNIT – II: ROBOT DRIVE SYSTEMS AND END EFFECTORS	**(9 Periods)**
Functions of drive system – Types of Drives – Hydraulic drives – Pneumatic drives – Mechanical drives - Electrical drives: DC motors and transfer functions, Stepper motor - Drive mechanisms – Industrial applications of vision controlled robotic systems - End effectors – Classification of end effectors – Drive system used for Grippers – Mechanical gripper - Vacuum gripper – Adhesive gripper - Magnetic gripper : Hooks, scoops and other miscellaneous devices – Gripper force analysis and gripper design.	
UNIT – III: ROBOT CONFIGURATIONS AND APPLICATIONS	**(9 Periods)**
Polar configuration – Cylindrical configuration – Spherical configuration – Articulated robot (joined arm) – SCARA robot - Delta configuration – Cartesian coordinate – Advantages and disadvantages of each configuration – Configuration for various applications.	
UNIT – IV: INDUSTRIAL CONTROLLERS – I	**(9 Periods)**
Open and closed loop control – Linear control schemes – Partitioned PD control scheme – PID control scheme – Computed torque control – Force control of robotic manipulator - Industrial controllers – Introduction to RIO controllers – platform – connection and configuration controllers - Interfacing protocol based Analog and digital sensors – Acquiring and data logging from sensors – creating standalone applications.	
UNIT – V: INDUSTRIAL CONTROLLERS – II	**(9 Periods)**
PLC - mode of operation – Programming & sequence control – Instruction set – Scam time – Timers – Counters – Interfacing with Input/output devices – Interfacing with sensors – Interfacing with Actuators – Interfacing with Human Machine Interface – Commissioning and operational safety of PLC – SCADA.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45Periods

TEXT BOOKS:

1. *R.K.Mittal ,I.J.Nagrath,* ***Robotics and Control****, Tata McGraw Hill, 2017*
2. *John J. Craig,* ***Introduction to Robotics Mechanics and Control*** *, Second Edition, 2004.*

REFERENCE BOOKS:

1. *Groover, M.P.* ***"Industrial Robotics – Technology, Programming and Applications"****, McGraw-Hill, 2012.*
2. *Cameron Hughes, Trarey Hughes,* ***"Robot Programming"****, Pearson, 5th Edition., 2016.*
3. *Richard D.Klafter, Thomas A.Chmielewski and MichealNegin,* ***"Robotic engineering –An Integrated Approach"****, Prentice Hall Inc, Englewoods Cliffs, 2005.*
4. *S.R.Deb,* ***Robotics Technology and Flexible Automation.***
5. *Ashitava Ghosal,* ***Robotics – Fundamental Concepts and Analysis.***

COURSE OUTCOMES:

On completion of this course, students will be able to:

CO1: Understand the robots anatomy and sensors selection of various applications.
CO2: Control the robot actuation by selecting appropriate drives and end effectors.
CO3: Understand different robot configurations and their applications.
CO4: Understand the basic robotic controllers.
CO5: Select and use correct controller units to operate the Industrial Robot.

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	H	H	L	M	-	-	-	M	-	L	L
CO2	M	L	M	L	M	H	L	M	-	M	-	M	L	-	L
CO3	M	M	M	L	H	H	M	M	-	M	-	M	-	L	L
CO4	M	L	M	H	M	H	M	M	L	M	L	M	M	M	M
CO5	M	L	H	H	H	M	M	M	L	M	L	M	M	M	M
18MPE$37	M	L	M	M	M	H	M	M	L	M	L	M	M	M	M
L-Low, M-Moderate (Medium), H-High															

18MPE$38	KINEMATICS AND DYNAMICS OF ROBOTICS

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

- To familiarize students with the concepts and techniques of robot mobility analysis, displacement analysis, velocity analysis, acceleration analysis and force analysis for various kinematics and arrangements .

UNIT – I: INTRODUCTION	**(9 Periods)**
Introduction to Mechanisms and Robotics - Configuration space and workspace - Defining robot structures - Configurations and configuration space - Degrees of freedom - Floating bases and virtual linkages - Joint limits and configuration space - Configurations for parallel mechanisms - End effectors and reachable workspaces - Mobility Analysis-I, Mobility Analysis-II	
UNIT – II: FORWARD KINEMATICS	**(9 Periods)**
Forward kinematics - 2D forward kinematics for a serial robot - Deriving the general-purpose formula - 2D forward kinematics for branched revolute robots - Handling 2D prismatic joints - 3D forward kinematics - 2RP manipulator - 6R manipulator - Kinematics convention - Planar robot convention - Denavit - Hartenberg convention - A single-pass forward kinematics algorithm	
UNIT – III: DISPLAMENT ANALYSIS OF ROBOTS	**(9 Periods)**
Displacement Analysis: constrained mechanisms and robots-I, Displacement Analysis: constrained mechanisms and robots-II, Displacement Analysis: constrained mechanisms and robots- III	
UNIT – IV: VELOCITY ANALYSIS OF ROBOTS	**(9 Periods)**
Velocity Analysis: constrained mechanisms and robots-I, Velocity Analysis: constrained mechanisms and robots-II, Velocity Analysis: constrained mechanisms and robots-III, Velocity Analysis: singularity and path generation	
UNIT – V: ACCELERATION ANALYSIS AND FORCE ANALYSIS OF ROBOTS	**(9 Periods)**
Acceleration Analysis, Force Analysis-I , Force Analysis-II, Coordinate Transformations and kinematics of serial robots	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Groover, M.P.* ***"Industrial Robotics – Technology, Programming and Applications"****, McGraw-Hill, 2012.*
2. *Lentin Joseph,* ***"Robot Operating System (ROS) for absolute beginners",*** *A press publishers, 2018.*

REFERENCE BOOKS:

1. *Cameron Hughes, Trarey Hughes,* ***"Robot Programming"****, Pearson, 5th Edition., 2016.*
2. *Richard D.Klafter, Thomas A.Chmielewski and Micheal Negin,* ***"Robotic engineering –An Integrated Approach"****, Prentice Hall Inc, Englewoods Cliffs, 2005.*
3. *Andrie de Vries, Joris Meys,* ***"R programming for Dummies"****, A wiley Brand.*
4. *S.R.Deb,* ***"Robotics Technology and Flexible Automation".***
5. *Ashitava Ghosal,* ***"Robotics – Fundamental Concepts and Analysis".***

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the robot configuration and mobility analysis

CO2: Understand the forward kinematics of the Robots

CO3: Utilize the displacement analysis for different mechanisms

CO4: Utilize the velocity analysis for different mechanisms

CO5: Utilize the acceleration and force analysis for different mechanisms

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	-	-	-	-	-	-	-	-	-	-	M	-	L	-
CO2	M	-	-	-	-	-	-	-	-	M	-	M	L	-	-
CO3	L	-	-	-	H	-	-	-	-	M	-	M	-	L	-
CO4	L	M	-	-	M	-	-	-	-	M	-	M	M	M	M
CO5	L	-	-	-		M	M	M	-	M	L	M	M	M	M
18MPE$38	L	M	-	-	M	M	M	M	-	M	L	M	M	M	M
L-Low, M-Moderate (Medium), H-High															

18MPE$39	ROBOT PROGRAMMING AND SIMULATION

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To familiarize the concept and techniques of robot programming and simulation methods, which is used to operate and select correct kinematic arrangements for varies robots.

UNIT – I: INTRODUCTION	**(9 Periods)**
Evolution of robots and robotics -Human arm characteristics – design and control issues – Manipulation and control – Programming robots – Coordinate frames – Mapping between rotated frames, translated frames, rotated and translated frames – description of object in space – transformation vectors for rotation, translation, combined rotation and translational – Fundamental rotation matrices – Principal axis rotation, fixed angle representation, Euler angle representation, Equivalent angle axis representation	
UNIT – II: ROBOT PROGRAMMING	**(9 Periods)**
Forward and inverse kinematic modelling of the manipulator –Lead through programming, Robot programming languages; VAL programming, motion commands, sensor commands, end effecter commands, simple programs for loading, unloading and palletizing operations, Advances in Robot Programming – RoboDK Simulation Software overview.	
UNIT – III: FIELD PROGRAMMABLE GATE ARRAY (FPGA) AND REAL TIME (RT) CONTROLLER PROGRAMMING	**(9 Periods)**
Introduction to FPGA – Architecture – operations in FPGA programming – FPGA programming in LabVIEW and implementation in myRIO – Introduction to RT controllers – Architecture – Programming RT controllers – creating standalone applications. – Introduction about R programming and its uses in Robotics.	
UNIT – IV: INTRODUCTION TO ROBOTICS VISION SYSTEM	**(9 Periods)**
Introduction to Machine Vision; functions, basics of image – image processing – Histograms – gray scale – Color – Equalization – Smoothing and blurring / filtering – Averaging, Gaussian, Median, Bilateral – Thresholding –Simple, Adaptive – Gradients and Edge detection – Laplacian, Sobel – Contours – Camera calibration – OpenCV library implementation using Python – Coordinates manipulation.	
UNIT – V: INTEGRATION OF ROBOT OPERATING SYSTEM (ROS) AND COMPUTER VISION	**(9 Periods)**
Introduction to ROS – Example problems to practice in ROS - Installation – CV bridge – Creating and Building package - Image publisher node – Image subscriber node – Nodes building and launching – Building real-world applications.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. Groover, M.P. ***"Industrial Robotics – Technology, Programming and Applications"****, McGraw-Hill, 2012.*

2. Lentin Joseph, **Robot Operating System (ROS) for absolute beginners",** A press publishers, 2018.

REFERENCE BOOKS:

1. *Cameron Hughes, Trarey Hughes,* ***"Robot Programming"****, Pearson, 5th Edition., 2016.*
2. *Richard D.Klafter, Thomas A.Chmielewski and MichealNegin,* ***"Robotic engineering –An Integrated Approach"****, Prentice Hall Inc, Englewoods Cliffs, 2005.*
3. *Andrie de Vries, Joris Meys,* ***"R programming for Dummies"****, A wileyBrand.*
4. *S.R.Deb,* ***"Robotics Technology and Flexible Automation".***
5. *Ashitava Ghosal,* ***"Robotics – Fundamental Concepts and Analysis".***

COURSE OUTCOMES:

On completion of this course, students will be able to:

CO1: Understand the characteristics and motion of robots with respect to coordinates.

CO2: Able tocreate the programming for basic movements of robots and simulate.

CO3: Utilize the FPGA programming and RT controllers for robotic applications.

CO4: Develop algorithms to extract features and data from image vision and manipulate.

CO5: Utilize the ROS environment and computer vision for robotic applications.

COURSE ARTICULATION MATRIX

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	H	-	L	L	M	L	-	M	L	M	H	L
CO2	M	H	M	H	M	H	L	-	L	M	H	M	H	H	L
CO3	L	M	M	H	H	H	-	-	L	M	H	M	M	H	L
CO4	L	M	M	H	M	M	M	-	L	M	H	M	M	H	L
CO5	L	M	M	H	H	H	M	L	L	M	H	M	H	H	L
18MPE$39	L	M	M	H	M	M	M	L	L	M	H	M	M	H	L
L-Low, M-Moderate (Medium), H-High															

18MPE$40	ROBOTS APPLICATION AND MAINTENANCE

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To impart knowledge on the various applications of robots and the concept of robots maintenance

UNIT – I: ROBOTS MATERIAL HANDLING SYSTEMS	**(9 Periods)**
Types of industrial robots - Load handling capacity, general considerations in Robotic material handling - material transfer - machine loading and unloading - CNC machine tool loading - Robot centered cell - Case Studies.	
UNIT – II: ROBOTS FOR INSPECTION	**(9 Periods)**
Robotic vision systems - image representation - object recognition and categorization - depth measurement, image data compression - visual inspection - software considerations - Case Studies.	
UNIT – III: ROBOTS FOR PROCESSING APPLICATIONS	**(9 Periods)**
Application of robots in continuous arc welding - Spot welding, Spray painting - Assembly application: Task, peg in hole assembly, steps in assembly – compliance – Cleaning - robot for underwater applications - medical applications - military applications - Case Studies.	
UNIT – IV: ROBOTS SELECTION CRETERIA	**(9 Periods)**
Impact of robot on industry and society - Factors influencing the robot - robot performance testing - Customizing the industrial robot as per application - Economic analysis of robots- pay back and rate of return method - Industrial case studies of customization and trending application of robots.	
UNIT – V: ROBOTS MAINTENANCE	**(9 Periods)**
Breakdown, preventive, predictive maintenance – checklist, schedule, procedure. Trouble shooting - robot maintenance costs - Implementation of robots in industries - safety considerations for robot operations, safety codes.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. Richaerd D Klafter, Thomas Achmielewski and Mickael Negin, ***"Robotic Engineering – An Integrated Approach"*** *Prentice Hall India, New Delhi, 2001.*

2. M.P.Groover, M.Weiss, R.N. Nageland N. Godrej, ***"Industrial Robotics"****, McGraw-Hill Singapore, 2017.*

REFERENCES:

1. *S.R. Deb,* ***"Robotics Technology and Flexible Automation",*** *Tata McGraw-Hill Education., 2009.*

2. K. K.Appu Kuttan, ***"Robotics"****, I K International, 2007.*

3. Mark R. Miller; Rex Miller, ***"Robots and Robotics: Principles, Systems, and Industrial Applications",*** *McGraw-Hill Education, 2017.*

4. Y. S. Nof, ***"Handbook of Industrial Robotics"*** *2nd Edition, John Wiley, 2013.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Select the robot for the material handling applications.

CO2: Apply the knowledge on robots in machine vision applications.

CO3: Make use of robots in processing applications.

CO4: Identify the robot for the customized applications.

CO5: Take part in the preventive maintenance and troubleshooting of robots.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	H	M	M	M	M	L	L	L	M	M	M	M	M
CO2	M	M	H	M	M	M	M	L	L	L	M	M	M	M	M
CO3	M	M	H	M	M	M	M	L	L	L	M	M	M	M	M
CO4	M	M	H	M	M	M	M	L	L	L	M	M	M	M	M
CO5	M	M	H	M	M	M	M	L	L	L	M	M	M	M	M
18MPE$40	M	M	H	M	M	M	M	L	L	L	M	M	M	M	M
L-Low, M-Moderate (Medium), H-High															

18MPE$41	DRONE TECHNOLOGY

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To inculcate specialized knowledge in an unmanned aircraft system for the societal usage and to introduce the custom design and control of the unmanned aerial vehicle for the future application

UNIT – I : INTRODUCTION IN UAV	**(9 Periods)**
UAV – Applications of UAV – needs of unmanned aircraft – The systemic basis UAS – System Composition - Transportation in UAV, Remotely .Piloted. Aircraft - Fixed-Wing, Vertical. Takeoff. and. Landing.	
UNIT – II : THE DESIGN OF UAV SYSTEMS	**(9 Periods)**
Aerodynamics and Airframe Configuration – Characteristics of Aircraft Types – Design Standards and Regularity Aspects – Aspects of Airframe Design – Design for Stealth – Pay Loads – Design for Reliability – Design for Manufacture and Development.	
UNIT – III : CONTROL AND COMMUNICATION SYSTEMS	**(9 Periods)**
Communication Systems in UAV – Control and Stability in UAV – Navigation Systems – Launch and Recovery – Control Stations – Support Equipment.	
UNIT – IV : TESTING FOR CERTIFICATION IN UAV	**(9 Periods)**
System Development and Certification – System Ground Testing – System In-flight Testing – Operational Trails and Full Certification – UAV System Deployment.	
UNIT – V : FUTURE OF UAV	**(9 Periods)**
Role of UAV in Army, Naval and Air Force – Civilian, Paramilitary and Commercial Roles – UAS Future – Future Prospects and Challenges – UAV Systems Continuing Evolution – UAS Organisations.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Reg Austin – **"Unmanned Aircraft Systems" -** Wiley Publications - 2010*
2. *Richard K. Barnhart – **"Introduction To Unmanned Aircraft System"** CRC Press, 2012*

REFERENCE BOOKS:

1. *Gundlach. Jay, **"Designing Unmanned Aircraft Systems"** American Institute of Aeronautics and Astronautics, 2012*
2. *Kimon P. Valavanis **"Intelligent Systems, Control and Automation: Science and Engineering 36"** Springer Publications, 2009*
3. *Dr Pascual Marqués **"Advanced UAV Aerodynamics, Flight Stability And Control "** John Wiley & Sons Ltd, 2017*
4. *Jacques Periaux ,Felipe Gonzalez, Dong Seop Chris Lee **"Evolutionary Optimization and Game Strategies for Advanced Multi-Disciplinary Design Applications to Aeronautics and UAV Design"** Springer Science+Business Media B.V. 2015*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Apply basic technologies to identify UAV system.

CO2: Design the UAV based on an aerodynamics and load..

CO3: Identify the control and communication system for UAV.

CO4: Apply the testing and certification of UAV.

CO5: Design the future requirement UAV for application.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	M	H	L	H	L	M	L	M	M	L	M	L	L
CO2	H	H	M	H	L	H	L	M	L	M	M	L	L	H	M
CO3	H	H	M	H	L	H	L	M	L	M	M	L	M	L	L
CO4	H	H	M	H	L	H	L	M	L	M	M	L	L	H	M
CO5	H	H	M	H	L	H	L	M	L	M	M	L	L	H	M
18MPE$41	H	H	M	H	L	H	L	M	L	M	M	L	L	H	M
L-Low, M-Moderate (Medium), H-High															

VERTICAL - IV

DIGITAL AND GREEN MANUFACTURING

18MPE$26	AUTOMATION IN MANUFACTURING

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

- Manufacturing Technology I
- Manufacturing Technology II

COURSE OBJECTIVES:

- To understand the importance of automation in the of field machine tool based Manufacturing.
- To get the knowledge of various elements of manufacturing automation – CAD/CAM, Sensors, pneumatics, hydraulics and CNC.
- To understand the basics of Automated guided vehicle systems and Industrial Robotics.

UNIT – I : AUTOMATION IN PRODUCTION SYSTEMS	**(9 Periods)**
Introduction: Current trends, CAD, CAM, CIM; Rigid automation: Part handling, Machine tools and Automated Material handling. Assembly, Flexible fixturing Basic Elements of an automated system – Levels of Automation – Lean Production and Just-In-Time Production.	
UNIT – II : CONTROL TECHNOLOGIES	**(9 Periods)**
Basic Elements of an Automated System-Levels of Automation, industrial control systems, sensors, actuators, and other control system components- Mechanical & Electro mechanical Systems, Pneumatics and Hydraulics, NC and NC part programming, CNC-Adaptive Control , DNC, Engineering analyses of NC Positioning Systems.	
UNIT – III : CELLULAR MANUFACTURING	**(9 Periods)**
Group Technology(GT), Part Families – Parts Classification and coding – Simple Problems in OPITZ Part Coding system – Production flow Analysis – Cellular Manufacturing – Composite part concept – Machine cell design and layout – Quantitative analysis in Cellular Manufacturing –Rank Order Clustering Method - Arranging Machines in a GT cell – Hollier Method – Simple Problems.	
UNIT – IV : FLEXIBLE MANUFACTURING SYSTEM	**(9 Periods)**
Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Implementation Issues – Quantitative analysis of Bottleneck Model on simple problems in FMS. Automated Guided Vehicle System (AGVS) – AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety	
UNIT – V : BASICS OF INDUSTRIAL ROBOTICS	**(9 Periods)**
Robot Anatomy and Related Attributes – Classification - Control systems – End Effectors – Sensors – Applications – Basics of Robot Part Programming – Robot Accuracy and Repeatability– Simple Problems- Introduction to Internet of Things.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Mikell P. Groover,* ***"Automation, Production Systems, and Computer-integrated Manufacturing",*** *prentice Hall*
2. *SeropeKalpakjian and Steven R. Schmid,* ***"Manufacturing – Engineering and Technology",*** *7th edition,Pearson*
3. *YoramKoren,* ***"Computer Control of Manufacturing System",*** *1st edition*

REFERENCE BOOKS:

1. *Kant Vajpayee S,* ***"Principles of Computer Integrated Manufacturing",*** *Prentice Hall India, 2003.*
2. *Radhakrishnan P, Subramanyan S.and Raju V.,* ***"CAD/CAM/CIM",*** *2nd Edition, New Age International (P) Ltd, New Delhi, 2000.*
3. *Gideon Halevi and Roland Weill,* ***"Principles of Process Planning – A Logical Approach"*** *Chapman & Hall, London, 1995.*
4. *Geoffrey Boothroyd,* ***"Assembly Automation and Product Design",*** *Second Edition, Taylor and Francis Group.*
5. *P Rao, N Tewari and T.K. Kundra,* ***"Computer Aided Manufacturing",*** *Tata McGraw Hill, 2000.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Get a comprehensive picture of computer based automation of manufacturing operations

CO2: Analyze mechanical, electromechanical, Pneumatic hydraulic and NC systems

CO3: Analyze Cellular manufacturing system

CO4: Analyze Flexible Manufacturing System and Automated Guided Vehicle System

CO5: Know basic controlling of Industrial Robotics

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	L	L	M	L	M	M	M	L	M	M	M	M	M
CO2	H	H	M	H	H	L	L	M	M	M	L	H	M	H	M
CO3	H	H	L	H	M	M	L	L	M	M	M	M	M	H	M
CO4	L	H	M	H	M	M	L	L	M	M	M	M	M	H	M
CO5	M	M	L	M	M	L	M	M	M	L	M	M	M	H	M
18MPE$26	H	H	L	M	H	M	H	H	M	H	M	M	M	M	M

L-Low, M-Moderate (Medium), H-High

18MPE$14	**LEAN MANUFACTURING** *(Common to MECH & PROD Branches)*

Category: PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

- Manufacturing Technology I
- Manufacturing Technology II

COURSE OBJECTIVES:

* To craft the students to acquire knowledge in lean manufacturing tools, understand various phases involved and methodology in implementing lean in manufacturing scenario

UNIT – I: FOUNDATION AND CONCEPTS OF LEAN	**(9 Periods)**
Historical evolution of lean manufacturing - Objectives of lean manufacturing - Key principles and implications of lean manufacturing - Traditional verses lean manufacturing. – Ford System – Growing Dysfunction — Ten steps to lean production - Necessity of Lean Production – Systems and lean thinking – Construction of Lean Production - Lean images and Lean Activities	
UNIT – II: LEAN TOOLS AND METHODOLOGY	**(9 Periods)**
Primary tools – Implementing 5S, Workplace organization – Stability - Just-In-Time – Takt time- One piece flow – Pull, Cellular systems, , Six Sigma. SMED: Single minute exchange of dies – theory and practice of the SMED system - TPM, Pillars of TPM, Conditions for TPM success, TPM implementation process - Overall Equipment Effectiveness - computation of OEE.	
UNIT – III: VALUE STREAM MAPPING	**(9 Periods)**
Process Mapping and Value Stream Mapping - Current state map – Future state map – VSM symbols – Mapping tips - Need for process maps - types and its construction - steps in preparing VSM - Comparison of CSVAM and FSVSA – Simulation scenario case studies	
UNIT – IV: INTEGRATED QUALITY	**(9 Periods)**
Development and necessity – Poke Yoke – mistake proofing - quality improvement – Leveling and Visual management. Common errors – Inspection system and Zone control – Using Poke Yokes – Jidoka implementation -Process capability study – Lean six sigma.	
UNIT – V: LEAN INVOLVEMENT AND CULTURE	**(9 Periods)**
Necessity of involvement – Waste of Humanity – Activities supporting involvement – Kaizen Circle Activity – Practical Kaizen Training – Key factors in Practical Kaizen Training – Lean Culture – Standardization – Standards and abnormality control – 'Five Why' analysis.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS

1. *Dennis P, **"Lean Production Simplified: A Plain Language Guide to the World's Most Powerful Production System"**, Productivity Press, New York, 2009.*
2. *Liker, J and Meier, D., **"The Toyota Way"** Field book, McGraw-Hill, 2010*
3. *N. Gopalakrishnan, **"Simplifed Lean Manufacture"**, PHI, 2010*

.

REFERENCE BOOKS

1. *Devadasan S R, Mohan Sivakumar V, Murugesh R and Shalij P R,* ***"Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities"****, Prentice Hall of India Learning Limited, 2012.*
2. *Gopalakrishnan N,* ***"Simplified Lean Manufacture: Elements, Rules, Tools and Implementation"****, Prentice Hall of India Learning Private Limited, 2010.*
3. *Bill Carreira,* ***"Lean Manufacturing that Works: Powerful Tools for Dramatically Reducing Wastes and Maximizing Profits"****, Prentice Hall of India Learning Private Limited, 2009.*
4. *Don Tapping, Tom Luyster and Tom Shuker,* ***"Value Stream Management: Eight Steps to Planning, Mapping and Sustaining Lean Improvements"****, Productivity Press, New York, USA, 2007.*

COURSE OUTCOMES:

On completion of this course, students will be able to

CO1: Describe about the origin and foundation of lean production.
CO2: Describe about stability and standards in lean system.
CO3: Describe about Just In Time (JIT) and its application in lean.
CO4: Describe about Jidoka and Poke Yoke.
CO5: Describe about lean involvement and culture.

COURSE ARTICULATION MATRIX:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	L	-	M	-	L	H	M	-	-	-	L	L	-	L	-
CO 2	M	L	-	M	L	M	L	-	L	-	-	M	M	M	-
CO 3	-	-	H	L	-	-	-	-	L	M	-	-	-	L	M
CO 4	H	L	-	M	-	M	-	L	-	-	-	M	L	H	-
CO5	-	M	H	-	L	-	L	-	L	-	-	-	-	-	-
18MPE$14	M	L	M	M	L	M	L	L	L	M	L	M	L	M	L

L-Low, M-Moderate (Medium), H-High

18MPE$42	GREEN MANUFACTURING DESIGN AND PRACTICES

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To introduce the concept of environmental design andto impart knowledge on concept of green co-rating and its need

UNIT – I : DESIGN FOR ENVIRONMENT AND LIFE CYCLE ASSESSMENT	**(9 Periods)**
Environmental effects of design -selection of natural friendly material - Eco design - Environmental damage Material flow and cycles – Material recycling – Emission less manufacturing- Industrial Ecology – Pollution prevention – Reduction of toxic emission – design for recycle. Life Cycle Assessment - Multipath way and Cumulative Risk Assessment.	
UNIT – II : AIR POLLUTION SAMPLING AND MEASUREMENT	**(9 Periods)**
Primary and Secondary Pollutants, Automobile Pollutants, Industrial Pollution, Ambient air quality Standards, Temperature lapse Rates and Stability wind velocity and turbulence-Pump behavior dispersion of air Pollutants-solution to the atmosphere dispersion equation-the Gaussian Plume Model, Air pollution sampling-collection of gaseous air pollutants-collection of particulate pollutants-stock sampling, analysis of air pollutants-sulfur dioxide- nitrogen dioxide, carbon monoxide, oxidants and ozone	
UNIT – III : NOISE POLLUTION AND CONTROL	**(9 Periods)**
Frequency and Sound Levels, Units of Noise based power radio, contours of Loudness. Effect of human, Environment and properties, Measuring Instruments for frequency and Noise levels, Masking of sound, Types, Kinetics, Selection of different reactors used for waste treatment, Treatment of noise at source, Path and Reception, Sources of noise, Effects of noise-Occupational Health hazards, thermal Comforts, Heat Island Effects, Radiation Effects.	
UNIT : IVWATER DEMAND AND WATER QUALITY	**(9 Periods)**
Factors affecting consumption, Variation, Contaminants in water, Nitrates, Fluorides, Detergents, taste and odour, Radio activity in water, Criteria, for different impurities in water for portable and non-portable use, Point and non-point Source of pollution, Major pollutants of Water, Water Quality Requirement for different uses, Global water crisis issues.	
UNIT V : GREEN CO-RATING	**(9 Periods)**
Ecological Footprint - Need For Green Co-Rating – Green Co-Rating System – Intent – System Approach – Weightage- Assessment Process – Types Of Rating – Green Co-Benefits – Case Studies Of Green Co-Rating	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. Gradel.T.E. and B.R. Allenby – ***"Industrial Ecology"*** *– Prentice Hall – 2010*

2. ***"World Commission on Environment and Development(WCED), Our Common Future"****, Oxford University Press 2005.*

REFERENCE BOOKS:

1. ***"Green and Sustainable Manufacturing of Advanced Material"****, Mrityunjay Singh, Tatsuki Ohji, Rajiv Asthana1st Edition - August 18, 2015*
2. ***"Sustainable Manufacturing Concepts"****, Tools, Methods and Case Studies,s.vinoth, 2021*
3. ***"Lean and Green Manufacturing",*** *Dr. Kaliyan Mathiyazhagan, Dr. K. E. K. Vimal, Dr. Harish Kumar, Dr. Anbanandam Ramesh, Veronica Agarwal,2022*
4. *Rao M.N. and Dutta A.K.* ***"Wastewater treatment"****, Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, Second Edition, 2006*
5. *Rao CS* ***"Environmental Pollution Control Engineering"-****, Wiley Eastern Ltd., New Delhi, 2006. 6. Lewis H Bell and Douglas H Bell, Industrial noise control, Fundamentals and applications, Marcel Decker, 1994.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Know the environmental design and selection of eco-friendly materials

CO2: Analyze manufacturing processes towards minimization or prevention of air pollution.

CO3: Understand concepts in green sustainable manufacturing, polices, best practices for green sustainable manufacturing, lean manufacturing, green energy, sustainable manufacturing for best practices.

CO4: To impart best practices for sustainable green manufacturing in industries, understand polices for sustainable manufacturing.

CO5: Evaluate green co-rating and its benefits.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	L	L	M	L	M	M	M	L	M	M	M	M	M
CO2	H	H	M	H	H	L	L	M	M	M	L	H	M	H	M
CO3	H	H	L	H	M	M	L	L	M	M	M	M	M	H	M
CO4	L	H	M	H	M	M	L	L	M	M	M	M	M	H	M
CO5	M	M	L	M	M	L	M	M	M	L	M	M	M	H	M
18MPE$42	H	H	L	M	H	M	H	H	M	H	M	M	M	M	M
L-Low, M-Moderate (Medium), H-High															

18MPE$43	ENVIRONMENT SUSTAINABILITY AND IMPACT ASSESSMENT

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To emphasize the importance of impact assessment to promote sustainability and cleaner production with the help of awareness on carbon trading.

UNIT – I : SUSTAINABLE DEVELOPMENT	**(9 Periods)**
Concepts of Sustainable Development - Indicators of Sustainability – Sustainability Strategies, Barriers to Sustainability - Resource Degradation - Industrialization and Sustainable Development - Socio Economic Policies for Sustainable Development.	
UNIT – II : CLEANER PRODUCTION	**(9 Periods)**
Clean Development Mechanism - Principles and Concepts of Cleaner Production - Definition - Importance - Historical Evolution - Benefits - Promotion - Barriers - Source Reduction Techniques - Process and Equipment Optimization, Reuse, Recovery, Recycle, Raw Material Substitution.	
UNIT – III : CARBON TRADING	**(9 Periods)**
Green House Gases and Carbon Credit - Carbon Sequestration- Sustainable Development through Trade - Carbon Trading – Carbon footprint.	
UNIT – IV : INTRODUCTION, IMPACT IDENTIFICATION AND PREDICTION	**(9 Periods)**
Historical development of Environmental Impact Assessment (EIA). EIA in Project Cycle. Legal and Regulatory aspects in India. – Types and limitations of EIA – EIA process- screening –scoping - setting – analysis – mitigation. Matrices – Networks – Checklists –Cost benefit analysis Prediction tools for EIA – Mathematical modeling for impact prediction – Assessment of impacts – air – water – soil – noise – biological.	
UNIT – V : ENVIRONMENTAL RISK ASSESSMENT AND MANAGEMENT	**(9 Periods)**
Environmental risk assessment framework-Hazard identification -Dose Response Evaluation – Exposure Assessment – Exposure Factors, Tools for Environmental Risk Assessment– HAZOP and FEMA methods – Event tree and fault tree analysis – Multimedia and multipath way exposure modeling of contaminant- Risk Characterization Risk communication – Emergency Preparedness Plans –Design of risk management programs.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. ***"Safety, Health, and Environment",*** *NAPTA, 2nd Edition, Pearson Publications, 2019.*
2. ***"Environmental Impact Assessment"-*** *Theory and Practice,", Wathern, P, Taylor and Francis Group, U.K. 2015*

REFERENCE BOOKS:

1. *John Blewitt,* ***"Understanding Sustainable Development"****, Third edition, Taylor & Francis Ltd., 2017.*
2. *Francisco Jose Gomes da Silva,* ***"Cleaner Production: Toward a Better Future"****, Ronny Miguel Gouveia , Springer Publications, 2020.*

3. *Subramanian Senthilkannan Muthu,* ***"The Carbon Footprint Handbook"****, Taylor & Francis Ltd., 2015.*
4. ***"Methodologies in Hazard Identification and Risk Assessment"****, Raghavan K. V. and Khan A A by CLRI, 1990*
5. ***"Environmental Impact Assessment: Practical Solutions to Recurrent Problems",*** *Lawrence, D.P., John Wiley & Sons, Canada (2003)*
6. ***"Environmental Risk and Hazards",*** *Cutter, S.L Hall of India Pvt. Ltd., New Delhi, Bimal Kanti Paul 2011.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Implement the sustainable development through various strategies.
CO2: Execute various practices of cleaner production.
CO3: Evaluate carbon footprint to achieve sustainable development.
CO4: Interpret the importance of environment assessment studies in project development.
CO5: Evaluate the risk assessment based on dose response analysis

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	-	M	-	L	L	H	-	-	-	-	-	L	-	L
CO2	M	-	M	-	H	L	H	-	-	-	L	-	L	M	M
CO3	M	M	M	H	L	-	H	-	-	-	-	-	-	-	L
CO4	M	-	-	H	-	-	H	-	-	-	-	M	L	L	L
CO5	M	H	M	M	-	-	M	-	M	M	L	-	L	L	L
18MPE$43	M	M	M	H	L	L	H	-	M	M	L	M	L	L	L
L-Low, M-Moderate (Medium), H-High															

18MPE$44	ENERGY SAVING MACHINERY AND COMPONENTS

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To introduce the various energy saving machineries and components to the students for the purpose of conserving energy.

UNIT – I : BASICS OF ELECTRICAL ENERGY USAGE	**(9 Periods)**
Fuel to Power : Cascade Efficiency – Electricity Billing : Components and Costs – kVA – Need and Control – Determination of kVA demand and Consumption – Time of Day Tariff – Power Factor Basics – Penalty Concept for PF – PF Correction – Demand Side Management (a brief) - energy monitoring, measurement and analysis	
UNIT – II : TRANSFORMERS AND MOTORS	**(9 Periods)**
Transformer – Basics and Types – Performance Prediction - Energy Efficient Transformers - Motors : Specification and Selection – Efficiency / Load Curve – Load Estimation – Assessment of Motor Efficiency under operating conditions – Factors affecting performance – ill effects of Rewinding and Over sizing - Energy Efficient Motors – . Transmission Line Parameters – Transmission Line Losses.	
UNIT – III : FANS, PUMPS AND COMPRESSORS	**(9 Periods)**
Basics – Selection – Performance Evaluation – Cause for inefficient operation – scope for energy conservation – methods adopted for effecting ENCON – Economics of ENCON adoption in all the 3 utilities	
UNIT – IV : ILLUMINATION AND ENERGY EFFICIENT DEVICES	**(9 Periods)**
Specification of luminaries - Types - Efficacy - Selection and Application - ENCON Avenues and Economic Proposition - New Generation Luminaries (LED - Induction Lighting) - Soft Starters- Auto Star - Delta - Star Starters- APFC - Variable Speed and Frequency Drives - Time Sensors - Occupancy Sensors	
UNIT – V : CO2 MITIGATION AND CASE STUDIES	**(9 Periods)**
Evaluation for 3 / 4 Typical Sectors – PAT Scheme (an introduction) – CO2 Mitigation - Energy Conservation - Cost Factor. Case Studies on Industrial Energy Audit	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Hamies, **"Energy Auditing and Conservation ; Methods Measurements, management and Case Study"**, Hemisphere, Washington, 1980*
2. *Trivedi, PR and Jolka KR, **" Energy Management"**, Commonwealth Publication, New Delhi, 1997*

REFERENCE BOOKS:

1. *Handbook on **"Energy Efficiency"**, TERI, New Delhi, 2001*
2. *Peters, Kraushaar and Ristenen, **"Sustainable Energy, beta – test – draft, Energy and Problems of a Technical Society"**, 1993*
3. *Guide book for National Certification Examination for Energy Managers and Energy Auditors (www.energymanagertraining.com)*
4. *Nagrath IJ and Kothari DP, **"Power system engineering"**, TMH, 2007*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Acquire knowledge on various energy saving machinery and components.

CO2: Understand the various methods of conservation of energy.

CO3: Evaluate the performance and energy conservation of fans, pumps and compressors

CO4: Analysis the various energy efficiency devices

CO5: Evaluate CO2 mitigation and cost factor.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	M	M	H	H	L	L	L	M	M	M	L	M	H
CO2	M	M	M	M	M	M	M	L	L	L	H	M	M	M	M
CO3	H	M	M	M	M	M	M	L	L	M	M	L	M	L	M
CO4	M	H	M	M	M	H	M	L	M	L	M	M	M	L	M
CO5	H	M	M	H	L	H	H	M	L	M	H	M	H	L	M
18MPE$44	H	M	M	M	M	M	M	L	L	L	M	M	M	L	M
L-Low, M-Moderate (Medium), H-High															

18MPE$45	GREEN SUPPLY CHAIN MANAGEMENT

Category: PE

L	T	P	C
3	0	0	3

Course Objectives :

* To make the student learn the concept of supply chin management and to understand the ideas in shop floor by implementing them in the current industrial strategy. This also enables the student to learn the various models involved in industrial management

UNIT – I : INTRODUCTION	**(9 Periods)**
Introduction - Location Problems- Transportation Models -Quantitative Models- Distribution Models - Bin Packing - Travelling Salesman Problems - Vehicle Routeing Problems - Value of Information.	
UNIT – II : FORECASTING AND AGGREGATE PLANNING	**(9 Periods)**
Forecasting – Time series models – Simple Exponential smoothing – Linear Models, Regression, Holt's , seasonality – Winter's model, causal models, Goodness of forecast, Aggregate Planning- Tabular method- Dynamic Programming- Quadratic model- Demand and capacity planning	
UNIT – III : INVENTORY MODELS	**(9 Periods)**
Inventory Models – Costs, EOQ model -EOQ model graphs- Multiple item inventory- Constraint on numbers of orders – Constraint on money value, space, equal number of orders – Production consumption model with backordering- Economic lot scheduling problem, Supply Chain inventory	
UNIT – IV : INTEGRATED MODEL	**(9 Periods)**
Lot sizing – heuristics- Disaggregation– time varying demand- Safety stock – ROL for discrete demand distribution -Integrated model- ROL for normal distribution of LTD - delayed Product differentiation, substitution - Sequencing and scheduling – Assumptions, objectives and shop settings	
UNIT – V : JOB SHOP SCHEDULING	**(9 Periods)**
Single machine sequencing– Johnson's algorithm - Flow shop scheduling - Job shop scheduling – Gantt chart - Different dispatching rules – Shifting bottleneck heuristic - Line Balancing	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Dilworth B.James,* ***"Operations Management Design, Planning and Control for Manufacturing and Services",*** *Mcgraw Hill Inc., New York, 1992*
2. *Vollman T.E,* ***"Manufacturing Planning and Control Systems",*** *Galgotia Publications, 2002.*

REFERENCE BOOKS:

1. *R.Panneerselvam,* ***"Production & Operations Management"****, 3rd Edition, PHI Learning Private Limited, New Delhi, 2016.*
2. *Elwood S.Buffa, and Rakesh K.Sarin,* ***"Modern Production/Operation Management"****, 8th Edition, John Wiley & Sons, 2020.*
3. *Don. T. Phillips, Ravindren, A and James Solberg****, "Operations Research"****, John Wiley & Sons, 2009.*
4. *Fourer, D.Gay and B. Kernighan, AMPL,* ***"A Modeling Language for Mathematical Programme"****, Brooks/Cole-Thomson, 2007.*
5. *J.K.Sharma* ***"Operation Research"*** *MacMilan., 2009*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basics of supply chain management.

CO2: Understand the various models in forecasting and aggregate planning

CO3: Identify the constrains in ordering the products.

CO4: Understand the various concepts on sequencing and scheduling

CO5: Analyze the line balancing technique in shop floor.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	H	-	-	-	L	-	L	-	M	M	H
CO2	H	M	L	L	H	-	-	-	L	-	L	-	M	M	H
CO3	H	M	L	L	L	-	-	-	L	-	M	-	M	M	H
CO4	H	H	L	L	H	-	-	-	L	-	M	-	H	H	H
CO5	H	H	L	L	H	-	-	-	L	L	M	-	L	L	H
18MPE$45	H	M	L	L	H	-	-	-	L	L	M	-	M	M	H
L-Low, M-Moderate (Medium), H-High															

VERTICAL - V

PROCESSES EQUIPMENT AND PIPING DESIGN

18MPE$46	DESIGN OF PRESSURE VESSELS

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To impart specialized knowledge in pressure vessels stresses, pressure vessels support, local load in pressure vessel, nozzle and shell design procedure for the steam generation systems.

UNIT – I : STRESSES IN PRESSURE VESSELS	**(9 Periods)**
Stress Analysis – Stress/Failure theories – Failures in Pressure Vessels – Loadings and Stresses on Pressure Vessels – Thermal Stresses - Discontinuity Stresses - Fatigue Analysis.	
UNIT – II : GENERAL DESIGN OF PRESSURE VESSELS	**(9 Periods)**
General Vessel Formulas – External Pressure Design – Calculations of MAP, MAWP, and Test Pressures – Stresses in Head – Design of Intermediate Heads, Toriconical Transitions, Flanges, Covers, Internal Support Beds – Nozzle Reinforcement – Minimum Design Metal Temperature (MDMT) – Estimating Weights of Vessel and Vessel Components.	
UNIT – III : DESIGN OF VESSEL SUPPORTS	**(9 Periods)**
Wind Design – Seismic Design for Vessels on Unbraced Legs, Braced Legs, Rings, Lugs and Skirt – Design of Horizontal Vessels on Saddles, Saddle Supports for Large Vessels, Base Plates for Legs, Lug Supports and Base Details for Vertical Vessels.	
UNIT – IV : SPECIAL DESIGNS	**(9 Periods)**
Stresses at Circumferential Ring Stiffeners – Design of Large-Diameter Nozzle openings, Design of Cone-Cylinder Intersections, Ring Girders, Baffles and Vessels with Refractory Linings – Tower Deflection – Vibrations of Tall Towers and Stacks.	
UNIT – V : LOCAL LOADS	**(9 Periods)**
Stresses at Circular Rings – Design of Partial Ring Stiffeners – Attachment Parameters – Stresses in Cylindrical and Spherical Shells from External Local Loads.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Dennis R. Moss – **"Pressure Vessels Design Manual"-** Butterworth Heinemann-Elsevier Publishing – 2013*
2. *Spence, J.; Tooth, A. S**. "Pressure Vessel Design : Concepts and Principles",** Taylor & Francis Routledge 1994*

REFERENCE BOOKS:

1. *Josef L. Zeman **"Pressure Vessel Design The Direct Route",** Henri van Dorssen Publisher, Energy Elsevie Ltd, 2006*
2. *Subhash Reddy Gaddam **"Design of Pressure Vessels",** CRC Press, 2020*
3. *SS Gill **"The Stress Analysis Of Pressure Vessels &amp"**; Pressure Vessels Components"pergamon press*
4. *John F Harvey,P.E **"Theory And Design Of Pressure Vessels",** Van Nostrand Reinhold publications, 2001*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze the stresses in pressure vessel parts.

CO2: Apply the general design concept to the pressure vessels

CO3: Apply concept to pressure vessel supports design

CO4: Analyse the additional parts selection and application

CO5: Analyse the local loads cause and effect on the shells.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	-	-	M	-	M	-	-	-	-	L	H	L	L	M	H
CO2	M	M	M	-	L	-	-	-	-	M	-	-	H	M	H
CO3	M	M	M	-	L	-	-	-	-	M	-	-	H	M	H
CO4	M	M	M	-	L	-	-	-	-	M	-	-	H	M	H
CO5	M	M	M	-	L	-	-	-	-	M	-	-	H	M	H
18MPE$46	M	M	M	-	L	-	-	-	-	M	H	L	H	M	H
L-Low, M-Moderate (Medium), H-High															

18MPE$47	FAILURE ANALYSIS AND NDT TECHNIQUES

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

- Ability to understand the root-cause for the real world metallurgical failures and to understand the different nondestructive testing techniques and associated practical applications.

UNIT – I : FAILURE ANALYSIS – I	**(9 Periods)**
Causes of materials failure – Characteristics of ductile and brittle failure – Optical, scanning and transmission electron fractrographic features of ductile and brittle fracture – Fatigue failure – Factors affecting fatigue failure – Loading conditions and types of fatigue failure. Failure analysis – Methodology – Tools and techniques of failure analysis.	
UNIT – II : FAILURE ANALYSIS – II	**(9 Periods)**
Corrosion related failures – Wear failure – High temperature failures – Materials design related failure – Failure data retrieval – Procedural steps for investigation of a failure for failure analysis – Defects in materials and their role in failure of engineering components – Case studies in failure analysis – Improvements derived from failure analysis – Application of fracture mechanics concepts to design for safety.	
UNIT – III : DYE PENETRANT AND MAGNETIC PARTICLE TESTING	**(9 Periods)**
Fundamentals non-destructive testing (NDT) – Scope and limitations of NDT – Visual examination methods and aids – Penetrant testing materials – Fluorescent penetrant testing method – Magnetizing technique – Fluorescent magnetic particle testing method.	
UNIT – IV : ULTRASONIC AND RADIOGRAPHIC TESTING	**(9 Periods)**
Principle of ultrasonic testing (UT) – Methods of UT – Defects in welded products by UT – Thickness determination by UT – X-ray and Gamma-Ray radiography – Industrial radiography techniques (RT) – Inspection techniques – Interpretation of radiographs – Safety in industrial radiography.	
UNIT – V : LEAK AND EDDY CURRENT TESTING	**(9 Periods)**
Definition of leak and types – Principle and various methods of pressure and leak testing – Application and limitation – Eddy current testing – Principle, instrument and techniques – Sensitivity – Application and limitations – Thermal methods of NDT.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Balan K P,* ***"Metallurgical Failure Analysis: Techniques and Case Studies",*** *BS Publications, 2019.*
2. *Prasad J, NairC. G. K.,* ***"Non-Destructive Test and Evaluation of Materials",*** *Tata McGraw-Hill Education, 2nd Edition, 2011.*

REFERENCE BOOKS:

1. *Colangelo, Heiser,* ***"Analysis of Metallurgical Failures"****, John Wiley & Sons, 2nd Edition,1986.*
2. Baldev Raj, Jayakumar T, Thavasimuthu M , ***"Practical Non-Destructive Testing"***, *Narosa Publishing, 1997.*
3. *Hellier C,* ***"Handbook of NonDestructive Evluation"****, McGraw-Hill Professional, 1st Edition, 2001.*
4. *Raj, B, Jayakumar T, Thavasimuthu M,* ***"Practical Non Destructive Testing"****, Alpha Science International Limited, 3rd Edition, 2002.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze the materials failure due to brittle, ductile and fatigue fractures.

CO2: Learn about the corrosion failure, wear and high temperature failures and analyze their role in failure of engineering components

CO3: Understand the liquid penetrant and magnetic particle testing methods which enable to carry out various inspection in accordance with the established procedures.

CO4: Apply the ultrasonic and radiography testing methods to perform inspection on applications.

CO5: Apply the leak and pressure testing and eddy current testing techniques for applications.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	M	L	M	H	L	-	-	-	-	-	-	L
CO2	M	L	L	M	L	M	H	L	-	-	-	-	-	-	L
CO3	-	-	-	M	L	M	H	L	-	-	-	-	-	-	L
CO4	-	-	-	M	L	M	H	L	-	-	-	-	-	-	L
CO5	-	-	-	M	L	M	H	L	-	-	-	-	-	-	L
18MPE$47	L	L	L	H	H	H	H	H	-	-	-	-	-	-	H
L-Low, M-Moderate (Medium), H-High															

18MPE$48	MATERIAL PROCESSING AND SOLID PROCESSING EQUIPMENT

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To know the need for use, application and design of different material handling techniques, equipments and machines for common use and in industrial sector.

UNIT – I : MATERIALS HANDLING EQUIPMENT	**(9 Periods)**
Introduction – Importance of material handling – Principle of material handling – Factors influences the choice of material handling - Types - Selection and applications – Scope of material handling.	
UNIT – II : DESIGN OF LOAD HANDLING ATTACHMENTS AND HOIST DRIVES	**(9 Periods)**
Design of forged hooks and eye hooks - crane grabs - lifting magnets - Grabbing attachments - Design of arresting gear. Hand and power drives - Travelling gear - Rail travelling mechanism - cantilever and monorail cranes -selecting the motor ratings.	
UNIT – III : CONVEYORS	**(9 Periods)**
Types - description - design and applications of Belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.	
UNIT – IV : ELEVATORS	**(9 Periods)**
Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices - Design of fork lift trucks.	
UNIT – V : SOLID PROCESSING EQUIPMENTS	**(9 Periods)**
Jaw and roll crushers – Size and power rating, Capacity estimation, Critical operating speed, Power consumption estimation. Tubular ball mill – Design and Estimation of capacity, Electrical drive of ball mill. Screening and classifiers – basic design features, operation of straight screens and classifiers – capacity and selection. Introduction to Solid – Liquid Separation – Thickening, Filtration, Gravity separation, Magnetic and Electrostatic separation.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Rudenko,N.,**"Materials handling equipment"**,Envee Publishers,1970*
2. *Spivakovsy,A.O.and Dyachkov,V.K., **"Conveying Machines"**, Volumes I and II*

REFERENCE BOOKS:

1. *Jacob Fruciitbaum, **"Bulk Materials Handling Handbook"** Springer,2013.*
2. *J. Verschoof, **"Cranes : Design, Practice, and Maintenance"** Second Edition, Wiley, 2002.*
3. *A.Kulwiec,**"Materials Handling Handbook"**,Vol. 1 & 2, Second Edition, Wiley India Pvt Ltd, 2009.*
4. *Ashok Gupta, "Mineral Processing Design and Operations – An Introduction", Second Edition, Technology and Engineering, Elsevier,2016.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Appreciate the importance of material handling and select appropriate tools for specific application.

CO2: Design Load handling attachments and drives for hoists.

CO3: Design different types of conveyor system.

CO4: Design different types of elevators and its attachments.

CO5: Estimate the power rating and capacity of various solid processing equipment.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1			M		M					L	H	L	L	M	H
CO2	M	M	M		L					M			H	M	H
CO3	M	M	M		L					M			H	M	H
CO4	M	M	M		L					M			H	M	H
CO5	M	M	M		L					M			H	M	H
18MPE$48	M	M	M		L					M	H	L	H	M	H
L-Low, M-Moderate (Medium), H-High															

18MPE$49	ROTATING MACHINERY DESIGN

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To inculcate the required knowledge to know about the rotating machines analysis, data interpretation of machineries, sizing of steam turbines, compressors components and pumps performance.

UNIT – I : DESIGN AND ANALYSIS OF ROTATING MACHINES	**(9 Periods)**
Rotordynamic Analysis – Torsional Analysis – Hydrodynamic Bearings – Tower's Experiments – Reynolds Equation- Rotor Vibration - Natural Frequencies and Resonance - Gyroscopic Effects - Casing and Foundation Effects - Forced Response Analysis – Mechanical and Fluid Excitation Forces - Rotordynamic Stability - Sub synchronous Whirl & Whip.	
UNIT – II : UNDERSTANDING ROTATING MACHINERY	**(9 Periods)**
Pattern Recognition – Static Versus Dynamic Data – Trends with Step Changes – Upward and Downward Trends – Cyclic Trends – Induced Draft Fan Experiences Unpredictable Vibration – Erratic Vibration Related to Rotor Instability – Some Rules of Thumb.	
UNIT – III : STEAM TURBINES	**(9 Periods)**
How Steam Turbines Work – Steam Generation – Waste Heat Utilization - The Rankine Cycle - General Purpose Steam Turbine Sizing - General Purpose, Back Pressure, Steam Turbines - Single Stage Back Pressure Steam Turbine - Sizing Procedure.	
UNIT – IV : COMPRESSORS	**(9 Periods)**
Compressibility Factor (Z) – Ideal Gas Law – Visualizing Gas Flow - Operating Requirements - Critical Components - Aerodynamic Matching - Reciprocating Compressor - Load Ratings - Gas Loads - Non-Reversing Gas Loads - Non-Reversing Rod Conditions Matrix - Ways to Protect Your Compressor.	
UNIT – V : PUMPS	**(9 Periods)**
Use of Pumps – Centrifugal Pump – Head Versus Pressure – Centrifugal Pump Performance - Determining the Efficiency of a Motor-Driven Centrifugal Pump - Liquid Properties - Liquid Characteristics.	

Contact Periods:
Lecture: 45 Periods Tutorial:0 Periods Practical:0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Robert X. Perez – "**Design, Modeling and Reliability in Rotating Machinery**"- Wiley Publishing – 2016*
2. *Yahya, S.M., "**Turbines, Compressors and Fans**", Tata McGraw Hill Publishing Company, 2012*

REFERENCE BOOKS:

1. *Gerhard Schweitzer,Eric H. Maslen "**Magnetic Bearings: Theory, Design, and Application to Rotating Machinery**" Springer-Verlag Berlin Heidelberg publisher, 2009.*
2. *Earl Logan, Jr., "**Hand book of Turbo Machinery**", CRC Press, 2009.*
3. *Nesbitt., "**Handbook Of Pumps And Pumping**", Elsevier Sciencepublisher, 2013.*
4. *R.K. Turton., "**Principles of Turbomachinery**", Chapman & Hall Publication, 2012.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze the design and analysis of rotating machines

CO2: Apply and identify the vibration related to rotor instability

CO3: Analyse and decide the sizing of the steam turbine

CO4: Analyse and decide the sizing of the steam turbine

CO5: Identify the suitable pumps for the application.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	M	M	M	M	H	L	L	M	L	H	H	H	L
CO2	H	M	L	M	M	M	H	L	L	M	L	H	L	M	L
CO3	H	M	M	M	M	M	H	L	L	M	M	H	H	M	M
CO4	H	M	H	M	M	M	H	L	L	M	M	H	H	L	L
CO5	H	M	M	M	M	M	H	L	L	M	M	H	M	M	M
18MPE$49	H	M	M	M	M	M	H	L	L	M	M	H	H	M	L
L-Low, M-Moderate (Medium), H-High															

18MPE$50	THERMAL AND FIRED EQUIPMENT DESIGN

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To familiarize and appreciate different modes of heat and mass transfer and its applications on imparting the knowledge of combustion and burner design. To acquire the exposure in heat exchanger designs and cooling tower design.

UNIT – I : HEAT TRANSFER	**(9 Periods)**
Different modes of heat transfer in fluidized bed– bed to wall heat transfer – gas to solid heat transfer – radiant heat transfer – heat transfer to immersed surfaces. Methods for improvement – external heat exchangers.	
UNIT – II : COMBUSTION	**(9 Periods)**
Fluidized bed combustion and gasification–stages of combustion of particles–performance–start –up methods. Pressurized fluidized beds.	
UNIT – III : DESIGN OF FIRED EQUIPMENTS	**(9 Periods)**
Design of distributors–stoichiometric calculations–furnace and burner Design for different fuels-design of heating surfaces–gas solid separators.	
UNIT – IV : DESIGN OF HEAT EXCHANGERS	**(9 Periods)**
Heat transfer and pressure loss – flow configuration – effect of deviations from ideality – design of double pipe– shell and tube heat exchangers –design of compact heat exchangers, plate heat exchangers– performance influencing parameters– limitations.	
UNIT – V : DESIGN OF CONDENSERS AND COOLING TOWERS	**(9 Periods)**
Design of surface and evaporative condensers–cooling tower –performance characteristics	

Contact Periods:

Lecture: 45 Periods Tutorial:0 Periods Practical:0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Yunus Cengel, **"Heat Transfer"**, McGraw Hill Company, 2008*
2. *Frank P Incropera and David P. Dewitt, **"Fundamentals of Engineering Heat and Mass Transfer"**, John Wiley and Sons, 2010.*
3. *YoramKoren, **"Computer Control of Manufacturing System"**, 1st edition*

REFERENCE BOOKS:

1. *Ozisik M.N., **"Heat Transfer",** McGraw Hill Book Co., 2005*
2. *Yadav R., **"Heat and Mass Transfer"**, Central Publishing House, Allahabad, 2010*
3. *SadikKakac, Hongtan Liu, Anchasa Pramuanjaroenkij, **"Heat Exchangers Selection, Rating and Thermal Design"**, CRC Press,Third Edition,2012.*
4. *Ramesh K.Shah, Dušan P.Sekulić, **"Fundamentals of heat exchanger design"**, John Wiley & Sons, 2003.*
5. *Howard,J.R.(Ed), **"Fluidized Beds: Combustion and Applications"**, Applied Science Publishers, New York, 1983.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basic modes of heat transfer.

CO2: Understand the principles of combustion and its characteristics

CO3: Analyze the design parameters for burners and furnace.

CO4: Design heat exchangers and its suitable equipment's.

CO5: Evaluate performance characteristics of condenser and cooling tower.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	L	M	H	L	L	L	M	M	L	M	L	M	L	M	L
CO2	L	M	M	L	L	M	L	L	L	L	L	L	L	H	L
CO3	L	H	H	M	M	M	L	L	L	M	L	M	L	M	L
CO4	L	M	M	L	L	L	M	M	L	L	L	L	L	H	L
CO5	L	H	M	M	L	L	L	L	L	M	L	M	L	M	L
18MPE$50	L	M	M	L	L	L	L	L	L	M	L	M	L	M	L
L-Low, M-Moderate (Medium), H-High															

18MPE$05	INDUSTRIAL ENGINEERING

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* Enable the students to apply industrial engineering principles and quality tools in the work environment and work collaboratively.

UNIT–I:FORECASTING	**(9Periods)**
Characteristics and Principles - Qualitative Methods, Delphi Technique, Market Research-TimeSeries Methods- Moving Average, Exponential Smoothing,- Box Jenkins Method –auto regressive moving average (ARMA) or auto regressive integrated moving average(ARIMA)models– Fitting Regression Models-Measurement of Forecast Errors, Coefficient of Correlation-Problem solving.	
UNIT–II:FACILITIESPLANNINGANDWORKSTUDY	**(9 Periods)**
Factors affecting Site Location Decisions - Principles and Types of Layout - Layout Planning - Layout Tools and Computerised Layout Techniques - Design of Group Technology Layout - Line Balancing-Line Balancing Methods-Objectives of WorkStudy-Method Study Procedure, Recording Techniques - Motion Study - Principles of Motion Economy - Techniques of Work-measurement-TimeStudy-Synthesis Method-Analytical Estimating-Pre determined Motion Time System(PMTS)-Work Sampling Techniques.	
UNIT–III:LEANMANUFACTURING	**(9Periods)**
Elements of Just In Time (JIT) - Pull and Push System, Kanban System- Optimized Production Technology and Synchronous Manufacturing – Implementation of Six Sigma - Single Minute Exchange of Die (SMED) 5S concept - Concurrent Engineering- Cellular Manufacturing – Enablers of Agile Manufacturing – Rapid Manufacturing - Business process reengineering (BPR) - Basics of Supply Chain Management, Supply chain and "Keiretsu" – Enterprises Resources Planning (ERP) – Role of KAIZEN, Quality Circles and POKAYOKE in Modern Manufacturing–Seven wastes in Lean Manufacturing.	
UNIT–IV: AGGREGATEPRODUCTIONPLANNING	**(9Periods)**
Objectives of Aggregate Planning - Capacity Requirement Planning (CRP) Process - Types of Capacity Planning - Strategies for Aggregate Capacity Planning - Master Production Scheduling - Procedure for Developing MPS –Materials Requirements Planning (MRP-I),Issues in MRP, Designing and Managing the MRP System, Evaluation of MRP – Manufacturing Resources Planning (MRP-II).	
UNIT–V:SCHEDULINGOFOPERATIONS	**(9Periods)**
Operations Planning and Scheduling-Scheduling Techniques-Stages in Scheduling–Loading, Dispatching, Expediting-Finite Loading and Infinite Loading-Load Charts and Machine Loading Charts - Priority Sequencing -Dynamic Sequencing Rules - Batch Scheduling – Economic Batch Quantity (EBQ) or Economic Run Length (ERL) – Scheduling in Repetitive, Batch and Job Shop Manufacturing – Allocation of units for a single resource, allocation of multiple resources – Resource balancing- Flexible manufacturing system.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *R.Panneerselvam,* ***"Production &Operations Management"****,3rd Edition, PHI Learning Private Limited,NewDelhi,2012.*
2. *ElwoodS.Buffa,and RakeshK.Sarin,* ***"Modern Production /Operation Management"****, 8th Edition,John Wiley &Sons,2000.*

REFERENCE BOOKS:

1. *R DilworthB.James,* ***"Operations Management Design, Planning and Control for Manufacturing and Services",****McgrawHillInc.,NewYork,1992*
2. *VollmanT.E,* ***"Manufacturing Planning and Control Systems"****, Galgotia Publications,2002.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Apply the knowledge of Engineering and Sciences to improve the productivity of industries

CO2: Design a system to meet the desired needs within realistic constraints.

CO3: Function in multi disciplinary teams.

CO4: Use the techniques, skills and modern Engineering tools in manufacturing practice.

CO5: Perform as an effective Industrial Engineer integrating high and low

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	-	-	M	M	-	-	-	-	-	-	-	-	H	-
CO2	-	-	H	-	-	-	-	-	-	-	-	-	-	M	-
CO3	-	-	-	-	-	H	M	-	H	M	H	M	H	-	M
CO4	H	H	-	M	H	H	-	-	-	-	-	M	-	H	-
CO5	-	-	-	-	-	H	M	H	-	-	-	-	H	-	H
18MPE$05	L	L	L	L	L	M	L	L	L	L	L	L	L	M	L
L-Low, M-Moderate (Medium), H-High															

VERTICAL – VI

COMPUTATIONAL ENGINEERING

18MPE$51	COMPUTATIONAL SOLID MECHANICS

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To understand the Finite element methods solutions for elastic, linear and non linear elastic problems under various loading conditions.

UNIT – I: ELASTICITY	**(9 Periods)**
Stress-Strain relations and general equations of elasticity in Cartesian, Polar and curvilinear coordinates, differential equations of equilibrium-compatibility-boundary conditions-representation of three-dimensional stress of a tension generalized hook's law - St. Venant's principle - Airy's stress function. Energy methods.	
UNIT – II: THE FINITE ELEMENT METHOD BASICS	**(9 Periods)**
Derivation and implementation of a basic 2D FE code with triangular constant strain elements, Generalization of finite element procedures for linear elasticity: interpolation and numerical integration in 1D, 2D and 3D, Deriving finite element equations - constructing variational forms, Accuracy and convergence	
UNIT – III: FINITE ELEMENT FOR NON LINEAR ANALYSIS	**(9 Periods)**
Formulation of Incremental Equations of motions- Deformation Gradient, Stress Tensor analysis, Continuum Mechanics increamental Langrangian Formulations, Linearized Kinematics, Material Time Derivative.	
UNIT – IV: KINETICS OF FINITE ELEMENT NON LINEAR ANALYSIS	**(9 Periods)**
Cauchy Stress Tensor, Linearization of Principal of Virtual Work, Linearization of External Virtual Work General matrix Equations of Displacement, Work conjugacy, Structural Elements- Truss and Cabel Elements, Beam and axissymmetricShell Elements.	
UNIT – V: ITERATIVE SOLUTION METHODS	**(9 Periods)**
Newton Raphson Method, Damped Newton Raphson Method, Quasi Newton Method, Linear search Method, Gradient Flow Method, Nonlinear Least sqares, Collapse and Buckling Analysis, Effects of Element Distortation.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *K.J. Bathe**, "Finite Element Procedures",** 2nd Edn., Prentice Hall, 1996*
2. *Allan F. Bower**, "Applied Mechanics of Solids",** CRC Press Inc; 1st edition, 2009.*

REFERENCE BOOKS:

1. *T. Belythschko, W.K. Liu and B. Moran**, "Nonlinear Finite Elements for Continua and Structures",** Wiley, 2000.*

2. *Antonio J. Gil, J. Bonet, and Richard D. Wood**, "Nonlinear Solid Mechanics for Finite Element Analysis: Statics",** Cambridge University Press 2016*
3. *P. Wriggers**, "Nonlinear Finite Element Methods",** Springer, 2008.*
4. *Richard D.Klafter, Thomas A.Chmielewski and Micheal Negin**, "Robotic engineering –An Integrated Approach",** Prentice Hall Inc, Englewoods Cliffs, 2005**.***

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the fundamental concept of elasticity.
CO2: Know the fundamentals of Finite Element Methods for linear elastic problems.
CO3: Analyse the role of Finite Element Methods in kinetics of Non- Linear elastic problems.
CO4: Analyse the role of Finite Element Methods in kinematics of Non- Linear elastic problems.
CO5: Employ various iterative methods for solving practical problems of solid mechanics.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	-	L	-	-	L	-	-	M	L	L	M	L	M
CO2	H	M	-	L	L	-	L	-	-	M	L	L	L	M	M
CO3	H	M	-	L	L	-	L	-	-	M	L	L	M	L	M
CO4	H	M	-	L	L	-	L	-	-	M	L	L	M	M	M
CO5	H	M	-	L	L	-	L	-	-	M	L	L	M	M	M
18MPE$51	H	M	-	L	L	-	L	-	-	M	L	L	M	M	M
L-Low, M-Moderate (Medium), H-High															

18MPE$23	COMPUTATIONAL FLUID DYNAMICS

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To make the students to learn finite difference and finite volume discretized forms of CFD equations and their solutions and to provide the essential numerical background for solving the partial differential equations governing the fluid flow.

UNIT–I:FUNDAMENTALS OF CFD	**(9Periods)**
Basics of CFD, Governing equations of Fluid Dynamics–Continuity, Momentum and Energy Equations, Physical Boundary and initial conditions, overview of numerical methods-Mathematical behavior of PDEs on CFD–Elliptic, Parabolic and Hyperbolic equations.	
UNIT–II:DISCRETISATION TECHNIQUES AND SOLUTION METHODOLOGIES	**(9Periods)**
Methods of deriving discretization equations – Finite difference and Finite volume methods, Finite difference discretization of wave equation, Laplace equation, Burger's equation, numerical error andstabilityanalysis.Timedependentmethods–Explicit,Implicit–Crank–Nicolsonmethods, time split methods.	
UNIT–III:CFD TECHNIQUES	**(9Periods)**
Finite volume formulation of steady one-dimensional convection and Diffusion problems, Central, upwind, hybrid and power-law schemes – Discretization equations for two dimensional convection and diffusion. Representation of the pressure–Gradient term and continuity equation–Staggered grid–Momentum equations – Pressure and velocity corrections – Pressure – Correction equation. SIMPLE algorithm and its variants.	
UNIT–IV:TURBULENCE MODELING	**(9Periods)**
Time–averaged equation for turbulent flow, Turbulence models–Zero equation model, one equation model, two equation K- I models, and advanced models.	
UNIT–V:GRID GENERATION	**(9Periods)**
Choice of grid, grid oriented velocity components, Cartesian velocity components, staggered and collocated grid arrangements, Algebraic Methods – Methods – Differential Equation methods–Adaptive grids.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *John D. Anderson, Jr.,* ***"Computational Fluid Dynamics: The Basics with Applications"****, McGraw Higher Ed Publication, 1st Edition, 2012.*
2. *Suhas V. Patankar,* ***"Numerical Heat Transfer and Fluid Flow"****, Hemisphere Publishing Corporation, 1 st Edition, 2017.*

REFERENCE BOOKS:

1. *Versteeg H.K, and MalasekeraW.,* ***"An Introduction to Computational Fluid Dynamics: The Finite Volume Method"****, Pearson Publication, 2ndEdition, 2008.*
2. *D. A, Anderson, John C. Tannehill, Richard H. Pletcher,* ***"Computational Fluid Mechanics and Heat Transfer"****, CRC Press, 3rd Edition, 2012.*
3. *Muralidhar K, and Sundararajan T.,* ***"Computational Fluid Flow and Heat Transfer",*** *Narosa Publishing House, New Delhi, 2 nd Edition, 2014.*
4. *TaylorC, and T.G Hughes.,* ***"Finite Element Programming of the Navier-Stokes Equation",*** *Pineridge Press Limited, U.K., 1981.*
5. *Fletcher, Professor Clive A.J.,* ***"Computational Techniques for Fluid Dynamics",*** *Fundamental and General Techniques, Springer – Verlag, 1996.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Appreciate different types of PDEs that arise in fluid flow and heat transfer problems.

CO2: Design of Numerical Schemes for 1D model equations of flow fluid and implement large scale linear System solvers (iterative and direct)

CO3: Propose the concepts of numerical schemes for unsteady viscous flows.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	M	M	L	L	L	L	L	L	L	H	H	L
CO2	M	M	H	H	M	L	L	L	L	L	L	L	H	H	L
CO3	H	H	M	M	M	L	L	L	L	L	L	L	M	H	L
18MPE$23	H	H	H	M	M	L	L	L	L	L	L	L	H	H	L
L-Low, M-Moderate (Medium), H-High															

18MPE$52	THEORY ON COMPUTATIONAL AND VISUALISATION

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To make the student strong in programming and to learn other languages somewhat easily. To understand the various ideas in virtual constructors, destructors and advanced machine learning concepts.

UNIT – I : INTRODUCTION	**(9 Periods)**
Introduction & Algorithms- Flowchart and Basic programming fundamentals– Constants- Conditional Statements- Loops- Arrays - Single and Multidimensional- Basics of pointers - Arrays and Structures	
UNIT – II : SEQUENCE ANALYSIS	**(9 Periods)**
Pairwise alignment tools-Dot matrix analysis, Dynamic programming-Smith Waterman and Needleman Wunsch algorithm ,Heuristic methods- BLAST,FASTA; Multiple sequence alignment methods-Progressive alignment (Clustal)	
UNIT – III : CONTROL STATEMENTS AND FUNCTIONS	**(9 Periods)**
Control statements – Random number generator- Branching and loops – Range functions- Functions –User defined functions- passing parameters- return function- working with global variables and constants.	
UNIT – IV : INHERITANCE AND POLYMORPHISM	**(9 Periods)**
Defining derived classes – single, multiple, multilevel, hierarchical and hybrid inheritance – virtual base classes – abstract base classes – nesting of classes - pointers – pointers to objects – this pointer – pointers to derived classes – virtual functions – pure virtual functions virtual constructors and destructors.	
UNIT – V :MACHINE LEARNING	**(9 Periods)**
Genetic Algorithm, Neural networks, Artificial Intelligence, Hidden markov model -application in bio informatics	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *E.Balagurusamy,* ***"Object oriented Programming with C++",*** *McGraw Hill Education Ltd, 7th Edition 2017.*
2. *Lafort Robert,* ***"Object oriented programming in C++",*** *4th Edition.*

REFERENCE BOOKS:

1. *Alfred Aho, John Hopcroft, Jeffrey Ullman, Ritchie,* ***"Data Structures and Algorithms",*** *Addison-Wesley,2020.*
2. *R.Rajaram,* ***"Object Oriented Programming and C++",*** *New Age International 2nd edition, 2018.*
3. *K.R. Venugopal, Rajkumar, T. Ravishankar,* ***"Mastering C++",*** *Tata McGraw Hill Education, 2nd edition, 2016.*
4. *Yashavant P. Kanetkar,* ***"Let us C++",*** *BPB Publications, 2nd edition 2015.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basics of Arrays and structures.

CO2: Understand the basic principle behind sequence analysis

CO3: Identify various control statements and functions.

CO4: Understand the various concepts in virtual constructors and destructors.

CO5: Understand the advanced machine learning concept.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	L	L	H	L	L	-	-	-	L	-	H	H	H
CO2	H	L	L	M	H	H	L	-	-	-	L	-	H	H	H
CO3	H	M	M	M	L	H	L	-	-	-	L	-	H	M	H
CO4	H	M	M	H	L	L	L	-	-	-	M	-	H	M	H
CO5	H	M	L	H	L	L	L	-	-	-	M	-	H	H	H
18MPE$52	H	M	L	H	L	L	L	-	-	-	L	-	H	H	H
L-Low, M-Moderate (Medium), H-High															

18MPE$53	COMPUTATIONAL BIO - MECHANICS

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To provide the student with an overview of the state of the art approach for modeling the musculoskeletal system from a bio mechanical point of view. The student will be introduced to a range of modeling and experimental methods applied to a variety of bones and muscles.

UNIT – I : INTRODUCTION	**(9 Periods)**
Scope of mechanics in medicine - mechanics of bone structure - determination of in-vivo elastic modulus - Bio fluid mechanics - flow properties of blood - Anthropometry.	
UNIT – II : MECHANICS OF PHYSIOLOGICAL SYSTEMS	**(9 Periods)**
Heart valves - power developed by the heart - prosthetic valves - Constitutive equations for soft tissues - dynamics of fluid flow in cardiovascular system and effect of vibration – shear stresses in extra - corporal circuits.	
UNIT – III : ORTHOPAEDIC MECHANICS	**(9 Periods)**
Mechanical properties of cartilage - diffusion properties of articular cartilage - mechanical properties of bone - kinetics and kinematics of joints - Lubrication of joints	
UNIT – IV : MATHEMATICAL MODELS	**(9 Periods)**
Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Implementation Issues – Quantitative analysis of Bottleneck Model on simple problems in FMS. Automated Guided Vehicle System (AGVS) – AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety	
UNIT – V : ORTHOPAEDIC APPLICATIONS	**(9 Periods)**
Robot Anatomy and Related Attributes – Classification - Control systems – End Effectors – Sensors – Applications – Basics of Robot Part Programming – Robot Accuracy and Repeatability– Simple Problems- Introduction to Internet of Things.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *C. Ross Ether and Craig A.Simmons, **"Introductory Biomechanics from cells to organisms"**, Cambridge University Press, New Delhi, 2009.*
2. *Haufred Clynes, **"Bio-medical Engineering Systems"**, McGraw Hill, 1998*

REFERENCE BOOKS:

1. *Susan J Hall, **"Basics of Biomechanics"**, Mc Graw Hill Publishing.co. New York, 5th Edition, 2007.*
2. *Joseph D.Bronzino, **"Biomedical Engineering Fundamentals"**, Taylor& Francis, 2006.*
3. *Gideon Halevi and Roland Weill, **"Principles of Process Planning – A Logical Approach"** Chapman & Hall, London, 1995.*
4. *John Enderle, Susanblanchard, Joseph Bronzino, **"Introduction to Biomedical Engineering"**, Elsevier, 2005.*
5. *Michael J. Waites., **"Industrial Microbiology: An Introduction"**, Blackwell Publishing,2001.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the basics of computational bio mechanics.

CO2: Understand the effect of vibration in cardiovascular system.

CO3: Identify the types of joints.

CO4: Understand the various mathematical models in finite element analysis.

CO5: Understand the advance applications of computational bio mechanics.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	H	-	-	-	L	-	L	-	M	M	H
CO2	H	M	L	L	H	-	-	-	L	-	L	-	M	M	H
CO3	H	M	L	L	H	-	-	-	L	-	M	-	M	M	H
CO4	H	H	L	L	H	-	-	-	L	-	M	-	H	H	H
CO5	H	H	L	L	H	-	-	-	L	L	M	-	L	L	H
18MPE$53	H	H	L	L	H	-	-	-	L	L	M	-	M	M	H
L-Low, M-Moderate (Medium), H-High															

18MPE$54	CAD AND CAE

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

* To understand the fundamentals of CAD, concepts of graphic standards, geometric modelling techniques and their engineering applications.

UNIT – I: INTRODUCTION	**(9 Periods)**
Definition and scope of CAD/CAM, Introduction to design process and role of computers in the design process. CAD data exchange - Graphics standards - Graphical Kernel System (GKS) - standards for exchange images Open Graphics Library (OpenGL) - Data exchange format - IGES.	
UNIT – II: GEOMETRIC MODELLING	**(9 Periods)**
Modelling Techniques - Wire frame modeling - Surface Modelling - Solid Modelling - sketching - Parameters and Dimensions - Datum Features - Geometric constraints. 2D and 3D transformations homogeneous coordinates - Translation - Scaling - Rotation - Problems.	
UNIT – III: SURFACE MODELLING	**(9 Periods)**
Parametric representation of analytic and synthetic curves - surface manipulation - Bezier curve- B-spline curves-rational curves-Techniques for surface modeling – surface patch - Coons and bicubic patches- - Design and engineering applications.	
UNIT – IV: SOLID MODELLING	**(9 Periods)**
Geometry and topology - Solid entities - Boundary representation- constructive solid geometry - sweep representation- analytical solid modelling- Design and engineering applications - Case studies.	
UNIT – V: COMPUTER AIDED ENGINEERING	**(9 Periods)**
Introduction - modern computational tools used for design and analysis - product design with solid modeling- finite element analysis - mechanism simulation and interface checking - Case studies.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Ibrahim Zeid and R. Sivasubramanian, **"CAD/CAM Theory and Practice",** Revised First special Indian Edition, Tata McGraw Hill Publication, 2007*
2. *D.Hearn and M.P.Baker , **"Design of Computer Graphics",** Prentice Hall Inc., 1992YoramKoren, **"Computer Control of Manufacturing System"**, 1st edition*

REFERENCE BOOKS:

1. *Radhakrishnan P, Subramanyan S.and Raju V., **"CAD/CAM/CIM",** 2nd Edition, New Age International (P) Ltd, New Delhi, 2000.*
2. *Chris McMohan and Jimmi Browne, **"CAD/CAM Principles, Practice and Manufacturing***
3. *Radhakrishnan P, Subramanyan S. and Raju V., **"CAD/CAM/CIM",** 2nd Edition, New Age International (P) Ltd, New Delhi,2000.*
4. *Rogers, D. F., **"Procedural Elements for Computer Graphics",** McGraw Hill Publication, 2008.*
5. *William M Neumann and Robert F.Sproul **"Principles of Computer Graphics",** McGraw Hill Book Co. Singapore, 1989.*

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Get a Identify the software tools used for the CAD/CAE

CO2: Design a mechanical part using geometric modelling techniques.

CO3: Identify the tools used in surface modelling and their engineering applications.

CO4: Design a mechanical assembly using solid modelling and their engineering applications.

CO5: Analyze the mechanical design using modelling and finite element analysis.

COURSE ARTICULATION MATRIX

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	H	H	H	M	H	-	-	-	M	M	M	H	M
CO2	M	M	H	H	H	M	H	-	-	-	M	M	M	H	M
CO3	M	M	H	H	H	M	H	-	-	-	M	M	M	H	M
CO4	M	M	H	H	H	M	H	-	-	-	M	M	M	H	M
CO5	M	M	H	H	H	M	H	-	-	-	M	M	M	H	M
18MPE$54	M	M	H	H	H	M	H	-	-	-	M	M	M	H	M
L-Low, M-Moderate (Medium), H-High															

18MPE$55	MACHINE LEARNING (Common to Mech & CSE)

Category: PE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Basic underlying concepts, Characterise for machine learning algorithms.
- Neural networks, support vector machine and few machine learning tools.
- Bayesian techniques and Inference and learning algorithms for the hidden Markov Model.
- Instant based learning and clustering.
- Ensemble methods and reinforcement learning algorithms.

UNIT – I : INTRODUCTION, CONCEPT LEARNING	**(9 Periods)**
Introduction- Well-Posed learning problems, Designing a learning system, perspectives and Issues in machine learning. Types of machine learning – Concept Learning – version spaces and candidate elimination algorithm – inductive bias –machine learning tools-R, Scikit Learn	
UNIT – II : SUPERVISED LEARNING	**(9 Periods)**
Linear Regression – Classification – Support Vector Machines – Neural Network Representation – Perceptrons – Multilayer Networks and Back Propagation Algorithms – Decision tree Learning – issues in decision tree learning- K- Nearest Neighbor Learning – Locally Weighted Regression – Radial Basis Functions.	
UNIT – III : UNSUPERVISED LEARNING	**(9 Periods)**
Clustering- Mixture Densities- K-means clustering- Hierarchical Clustering-Distributional clustering - Association Rules - The Curse of dimensionality- Dimensionality reduction. -Principal Component Analysis.	
UNIT – IV : BAYESIAN AND PROBABILISTIC GRAPHICAL MODELS	**(9 Periods)**
Bayes Theorem – Concept Learning – Maximum Likelihood – Minimum Description Length Principle – Bayes Optimal Classifier – Gibbs Algorithm – Naïve Bayes Classifier– Bayesian Belief Network – EM Algorithm – Graphical models - Directed and undirected graphical model - Conditional Independence properties-Hidden Markov Models.	
UNIT – V : ENSEMBLE METHODS AND REINFORCED LEARNING	**(9 Periods)**
Ensemble Methods- basic concepts - popular learning algorithms - Evaluation and Comparison- Bagging - Boosting-Combination Methods - Averaging, Voting– Reinforcement Learning – introduction – Learning Task – Q-Learning – Temporal Difference Learning.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Tom Mitchell,* ***"Machine Learning"*** *McGraw-Hill, 2013.*
2. *Ethem Alpaydin,* ***"Introduction to Machine Learning"****, MIT Press, Third Edition, 2014.*

REFERENCE BOOKS:

1. *Zhi Hua Zhon,* ***"Ensemble Methods: Foundation and Algorithms",*** *CRC Press, 2012.*
2. *Kevin P. Murphy,* ***"Machine Learning: A Probabilistic Perspective",*** *MIT Press, 2012.*
3. *Trevor Hastie, Robert Tibshirani, Jerome Friedman,* ***"The Elements of Statistical Learning"****, Springer, Second Edition, 2011.*
4. *Richard Sutton and Andrew Barto,* ***"Reinforcement Learning: An introduction"****. MIT Press,2017.*

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1: Explain and discuss the basic concepts, the fundamental issues and challenges of machine learning algorithms and the Decision tree learning. **[Familiarity].**

CO2: Apply effectively neural networks and support Vector Machines for appropriate applications. **[Usage].**

CO3: Design and implement some basic machine learning algorithms using Machine learning tools**. [Usage].**

CO4: Apply Bayesian techniques and Hidden Markov Models.**[Usage].**

CO5: Discuss the basic concepts Instant based learning and Clustering**. [Familiarity].**

CO6: Explain and discuss the basic concepts and architecture of reinforcement learning algorithms and Ensembles Methods. **[Familiarity].**

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	H	H	H	H	H	L	-	M	M	-	-	M	H	H	H	H
CO2	H	H	H	H	H	L	-	M	M	-	-	M	H	H	H	H
CO3	H	H	H	H	H	L	-	M	M	-	-	M	H	H	H	H
CO4	H	H	H	H	H	L	-	M	M	-	-	M	H	H	H	H
CO5	H	H	H	H	H	L	-	M	M	-	-	M	H	H	H	H
CO6	H	H	H	H	H	L	-	M	M	-	-	M	H	H	H	H
18MPE$55	H	H	H	H	H	L	-	M	M	-	-	M	H	H	H	H

L - Low, M - Moderate (Medium), H - High