Savitribai Phule Pune University
Faculty of Science & Technology

Curriculum for
Fourth Year
Production (Sandwich) Engineering
(2019 Course)

(with effect from June 2023)

Savitribai Phule Pune University, Pune
BE (Production Sandwich Engineering)
2019 Course
(With effect from Academic Year 2022-23)

Semester-VII

Course Code	Course Name	Teaching Scheme (Hours/ Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Project	IN-Sem	End-Sem	TW	PR	OR	Total	TH	PR	Project	Total
411121	Manufacturing Automation	3			30	70				100	3			3
411122	Operations Research	3			30	70				100	3			3
411123	Elective III	3			30	70				100	3			3
411124	Elective IV	3			30	70				100	3			3
411125	Manufacturing Automation Lab		2				25	25		50		1		1
411126	Operations Research Lab		2				25	25		50		1		1
411127	Elective III Lab		2						25	25		1		1
411128	Elective IV Lab		2						25	25		1		1
411129	MOOCs						50			50		2		2
411130	Mini project			4			50		50	100			2	2
411131	Mandatory Audit Course 7	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		**12**	**8**	**4**	**120**	**280**	**150**	**50**	**100**	**700**	**12**	**6**	**2**	**20**

	Elective III		Elective IV
1	Additive Manufacturing	**1**	Creative Product Design
2	Industrial Robotics	**2**	Mechatronics
3	Reliability Engineering	**3**	CAD/CAM
4	Micro-Electro mechanical systems	**4**	Data analytics

Savitribai Phule Pune University, Pune
BE (Production Sandwich Engineering)
2019 Course
(With effect from Academic Year 2022-23)

Semester-VIII

Course Code	Course Name	Teaching Scheme (Hours/ Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Project	In-Sem	End-Sem	TW	PR	OR	Total	TH	TW	Project	Total
411132	Industrial In-plant * training		2*				150		150	300		6	6	12
411133	Project*						100		100	200			3	3
411134	Elective V				30	70				100	3			3
411135	Elective V lab						50			50		1		1
411136	Seminar 2						25		25	50		1		1
411137	Mandatory Audit Course 8	-	-	-	-	-	-	-	-	-	-	-	-	-
Total					**30**	**70**	**325**		**275**	**700**	**3**	**8**	**9**	**20**

Abbreviations:
TH : Theory TW : Term Work PR : Practical
OR : Oral TUT : Tutorial

Elective V
Supply Chain Management
Plant Engineering and Maintenance
Industrial Relation and Human Resource Management
Marketing mgmt.

*All students should report to College 2Hrs/per week/ per students.

411121 : Manufacturing Automation

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures : 03hours/week	Theory : 03	In-Sem : 30Marks
		End -Sem : 70Marks

Course objectives:

To learn Basic principles of Industrial hydraulics.
To study design of hydraulic circuits & selection of various components.
To study pneumatic systems & circuit.
To understand concept of programmable automation viz microprocessor & control.
To study various control system & learn of programmable logic control.
To get well verse with the factory automation methods & system

Course Outcomes: After learning this subject, the student will be able to:

Understand basic concepts of industrial hydraulics and pneumatics
Design the hydraulic and pneumatic circuits for given application
Use microprocessor and programmable logic controller for soft automation.
Apply electric, electronics and computer control systems used in automation.
Apply various innovative methods for factory automation

Unit I: Overview of Manufacturing **[7]**

Introduction to Production Systems, Automation in Production Systems, Overview of Manufacturing, Manufacturing Operations, Manufacturing Models and Metrics Automation, Mechatronics and Control Technologies: Introduction to Automation, Definition of Mechatronics, Mechatronics in Manufacturing, Products and Design, Review of Fundamentals of Electronics Industrial Control Systems, Hardware Components for Automation, Mechatronics and Process Control (Data Conversion Devices, Sensors, Micro-sensors, Transducers, Signal Processing Devices, Relays, Contactors and Timers), Data Acquisition, Actuators and Mechanisms

Unit II: Introduction to Hydraulic Systems **[7]**

Introduction of fluid power system, Properties of fluids, Fluids for hydraulic systems, governing laws. Standards in circuit diagram representation, hydraulic symbols, Working Principle, design and analysis of reservoir, pumps, filters, valves, actuators, accumulators, intensifiers.

Design and Analysis of Hydraulic Circuits.

Design considerations for hydraulic circuit, Detail analysis speed control, flow control, pressure control circuits, Industrial applications of hydraulic circuit design using proportional valves and servo valves.

Unit III: Pneumatic Systems **[7]**

Operational principles, Functions of different pneumatic components and selection, Valves for logic functions; Time delay valve; Examples of typical circuits using Displacement – Time and Travel-Step diagrams, cascade circuits, Construction of pneumatic controls and circuit diagrams for conveying, feeding, clamping, indexing, cutting and non-cutting operations.

Unit IV Programmable Automation (Processors). **[7]**

Overview of Microcomputer systems, Microcontroller, 8051 Microcontroller Architecture, 8051 Instruction set and interfacing, applications and assembly language programming of microcontroller

Unit V Material Handling and Identification Technologies **[7]**

Introduction to Material Handling, Principles of Material Handling, Material Transport Systems, Conventional and Automated Storage Systems, Engineering Analysis of Storage Systems, Automatic Identification and Data Capture Manufacturing Systems Introduction to Manufacturing Systems, Single Station Manufacturing Cells, Manual Assembly Lines: Single Model and Mixed Assembly Line Balancing, Automated Production Lines, Automated Assembly Systems.

UnitVI: Advance Automated Systems [7]

Large scale control systems: Supervisory control and data Acquisition (SCADA), Human machine interface (HMI), Remote Terminal Unit (RTU), Digital Communication Unit (DCU).

Artificial Intelligence in automation: Artificial Neural Networks, Fuzzy Logic, Image Processing

Text Books:

1. Kuo B.C., ―Automatic control systems‖, Prentice Hall India Pvt. Ltd., New Delhi, ISBN: 1305-5070-1
2. Peter Rohner, ―Industrial hydraulic control‖, Wiley Edition, 1995, ISBN: 0471334987
3. Mikell P Groover, ―Automation, Production System and Computer Integrated Manufacturing‖, Prentice Hall Publications, ISBN 9789332549814
4. Mujumdar S.R., ―Pneumatic System‖, Tata McGraw Hill, 2002 Edition. ISBN: 9780074602317
5. Gopal, ―Control Systems Engineering‖, Willey Eastern Ltd., ISBN 0-85226-605-7.
6. Reference Books:
7. Doebelin E.O, ―Measurement System, Application and Design‖, Tata McGraw Hill Publications Ltd., New Delhi, ISBN 0-07—17338-9.
8. Bolton W., ―Mechatronics Electronic Control Systems in Mechanical and Electrical Engineering‖, Pearson Education (Singapore) Pvt Ltd., ISBN 81-7808-339-6.
9. Rangan C.S., Sharma G.R., Mani V.S., ―Instrumentation - Devices and Systems‖, Tata McGraw Hill Publications Ltd., New Delhi, ISBN 0-07-463350-3.
10. Histand B.H., Alciatore D.G., ―Introduction to Mechatronics and Measurement Systems‖, ISBN 0-07-052910-8.
11. Johnson C.D., ―Process Control Instrumentation Technology‖, Prentice Hall of India pvt.Ltd., New Delhi, ISBN 81-203-0987-1.
12. HMT Mechatronics, HMT, ISBN 0-07-462147-5. 7. Vickers manual on hydraulic

411122:Operations Research

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks
		End -Sem:70Marks

Pre-requisites: Engineering Mathematics, Industrial Engineering & Management, Production Management

Course Outcomes: After learning this subject, the student will be able to:

Formulate and solve linear programming problem.
Formulate and solve transportation and assignment problem
Evaluate integer, dynamic, goal and geometric programming
Plan optimum replacement strategies in various replacement situations.
Apply knowledge of decision making theory and game theory to real-world decision situations
Understand different queuing situations

Unit I: Linear programming (LP) **[7]**

Definition of Operations Research: Objectives, Simplex methods formaximization and minimization problems : Formulation, Degeneracyin L.P.,DualityinL.P.

Unit II: Transportation and Assignment problem **[7]**

Transportation problems-Use of various methods for solving transportation problem ,Degeneracy and its solution, Transshipment problem

Assignment problem- Solutions of various types of problems: Hungarian Method, Branch & Bound Technique, travelling sales man problem.

Unit III : Introduction to Integer, Dynamic and Non-linear programming **[7]**

Integer programming, Branch & Bound method, Cutting Plane method, Dynamic programming introduction, application, capital budgeting, different problems solved by dynamic programming, non linear programming, Geometric and goal programming, Definition, Introduction, Application of geometric and goal programming

Unit IV : Replacement models **[7]**

Replacement of capital equipment that deteriorates with time, Time value of money: Cases in which time value of money remains same and changes with constantrates during period. Group and individual replacement.

Unit V : Decision Theory and Games Theory **[7]**

Decision Theory: Steps in decision theory, Decision making under conditions of certainty, uncertainty and risk, maximum likelihood criterion ,Expected value criterion

Games Theory: Introduction, Terms and definitions, Solution methods

Unit VI : Queuing theory and Simulation **[7]**

Operating characteristics, Poissonsing leand multi channel queuing system (M/M/1):(∞/∞/FCFS) ,(M/M/1):(∞/∞/SIRO) ,(M/M/1):(N/∞/FCFS), (M/M/c):(N/∞/FCFS)

Monte Carlo simulation of Production quantity, Demand, Inventory, Queuing systems, Investment decision etc.

Text Books:

1. SharmaS.D.,(2012)OperationsResearch,KedarnathRamnathandcompanypublications,ISBN:978-9380803388
2. GuptaP.K.,HiraD.S.,(1976)OperationsResearch‖,SChandandCo.Ltd.,NewDelhiISBN:978-8121902816
3. Taha H.A.,(2016)Operations Research- An introduction, Pearson EducationLtd.ISBN:978-0134444017
4. P. Shankara Iyer,(2008)Operations Research Sigma Series, TataMcGraw-Hill.ISBN:,9781283922487
5. Rao, S. S.(2009)Engineering Optimization: Theory and Practice‖, John Wiley & Sons. ISBN: 978-0470183526
6. Reference Books:
7. Hillier F .S., Lieberman G.J.,(2005)Introduction to Operations Research‖ ,Tata McGraw-Hill,ISBN:978-0070600928
8. Wagner H.M.,(1975)Principles of Operations Research, Prentice-Hall India, ISBN: 978-0137095926,
9. BasuS.K.,PalD.K.,andBagchiH.,OperationsResearchforEngineers‖,OxfordandIBHPublishingCo.Pvt.Ltd.,ISBN81-204-1251-6.
10. Panneerselvam R.,(2004)Operations Research‖,Prentice Hall of India Ltd.,New Delhi. ISBN: 978-8120329287

411123: Elective III: Additive Manufacturing

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks End-Sem:70Marks

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Pre-requisites : Material Science, Computer Aided Design

Course Outcomes : After learning this subject, the student will be able to:
Identify the materials for used in additive manufacturing.
Identify the software for additive manufacturing and digitization techniques.
Identify industrial applications of liquid based additive manufacturing technology.
Identify industrial applications of solid based additive manufacturing technology.
Identify the industrial applications of powder based additive manufacturing.
Find applications of Bio-Additive Manufacturing-Computer Aided Tissue Engineering

UnitI:Introduction **[7]**

Overview – History - Need-Classification -Additive Manufacturing Technology in product development- Materials forAdditive Manufacturing Technology – Tooling – Applications,3D modeling ,Data Conversion, Checking and Preparing,Building,Postprocessing

UnitII:CAD & ReverseEngineering **[7]**

Basic Concept – Digitization techniques – Model Reconstruction – Data Processing for Additive Manufacturing Technology: CAD model preparation–Part Orientation and support generation–Model Slicing –Tool path Generation – Softwares for Additive Manufacturing Technology : MIMICS,MAGICS

UnitIII:Liquid Based Additive Manufacturing Systems **[7]**

Liquid based system – Stereolithography Apparatus (SLA)- Principle, process, advantages and applications , Cubital_sSolid Ground Curing(SGC),D-MEC_ sSolid Creation System(SCS), Meiko_ sRapidPrototyping Systemforthe Jewelry Industry, RapidFreeze Prototyping, Microfabrication

UnitIV : Solid Based Additive Manufacturing Systems **[7]**

Solid based system –Fused Deposition Modeling - Principle, process, advantages and applications, CubicTechnologies_ Laminated Object Manufacturing(LOM),Kira_s Paper Lamination Technology (PLT),3DSystems_Multi-Jet Modeling System(MJM),Beijing Yinhua_ sSlicing Solid Manufacturing(SSM), Melted Extrusion Modeling(MEM) and Multi-Functional RPM Systems(M-RPM)

UnitV : Powder Based Additive Manufacturing Systems **[7]**

Selective Laser Sintering – Principles of SLS process - Process, advantages and applications, Three Dimensional Printing - Principle, process, advantages and applications- Laser Engineered Net Shaping (LENS), Electron Beam Melting Unit IV:Solid Based Additive Manufacturing Systems

UnitVI:Medical and Bio-Additive Manufacturing **[7]**

Customized implants and prosthesis :Design and production. Bio-Additive Manufacturing-Computer Aided Tissue Engineering (CATE) – Case studies, Biomedical applications of AM-Operation Planning for Cancerous Brain Tumor Surgery, Planning Reconstructive Surgery with RP Technology, Craniofacial Reconstructive Surgery Planning, Biopsy Needle Housing, Knee Implants, Scaffolds for Tissue Engineering, Customized Tracheobronchial Stents, Inter-Vertebral Spacers, Cranium Implant.

Text Books:

1. ChuaC.K.,LeongK.F.,andLimC.S.,—Rapidprototyping:Principlesandapplications‖,ThirdEdition,WorldScientificPublishers,2010.
2. GebhardtA.,—Rapidprototyping‖,HanserGardenerPublications,2003.

Reference Books:

1. LiouL.W.and LiouF.W.,— Rapid Prototyping and Engineering applications : A tool box for prototype development‖ ,CRCPress,2007.
2. Kamrani A.K.and Nasr E.A.,—Rapid Prototyping : Theory and practical‖,Springer,2006.
3. Hilton P. D.and Jacobs P .F.,—Rapid Tooling: Technologies and Industrial Applications‖, CRC press, 2000.

411123:Elective III: Industrial Robotics

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks End-Sem:70Marks

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Pre-requisites:

Basic knowledge of Engineering drawing, Theory of Machines, Mechanics of Materials, Design of Machine Elements ,Kinematics of Manufacturing Machines

Course Objectives:

To study robot control systems, sensors & end effector,

To develop the ability to analyze and design the motion for robotic systems

To develop ability for robot programming

To impart basic knowledge of artificial intelligent tools, search strategies, knowledge Representation and their applications to robotics

Course Outcomes:

After learning this subject,the student will be able to:

Design evaluate performance of robotic control system

Able to use robot programming languages for robot programming

Able to select and use appropriate sensors and end effectors for given robotics application

Apply artificial intelligent tools, search strategies, knowledge representation to various robotics applications..

Unit1:Fundamentals of robotics **[7]**

Need of Automation,Laws of Robotics, History of Robots, Basic concepts - Robot anatomy - Robot configurations - Basic robot motions –Types of robots-Dynamic Properties, Types of drives - Applications - Material handling - processing - Assembly and Inspection – safety considerations.

UnitII:Robot Arm Kinematics **[7]**

Robot kinematics- Types-2D,3D Transformation, D-H Representation & Displacement Matrices for Standard Configurations, Forward kinematics and Inverse kinematics analysis of manipulators with two and three degrees of freedom(planar).

UnitIII:Sensors in Robotics **[7]**

Sensors-functioning, types, analysis and fields of applications. Tactile sensors, temperature sensors, Variable Pressure Light Converting Sensor, High Resolution Pneumatictactile Sensor,Sliptype Sensors, Piezoelectric Contact Sensors.Remote Sensor Compliance, Range & Proximity Sensors ,Electro-optical Sensors.

Unit IV: Robot Grippers **[7]**

Control system concepts - Analysis - control of joints - Adaptive and optimal control – End effectors - Classification - Mechanical - Magnetic -Vacuum - Adhesive - Drive systems – Force analysis and Gripper design..

Unit V: Robot Programming and Robot Interfacing **[7]**

Robot Programming: Methods of Programming the robot, Methods of defining positions in space, Motion interpolation,branching, Textual robot programming languages. Interfacing Robots with computers. Obstacle Avoidance: Lee's Algorithm ;Counter Path Definingusing 'via' point, blending Technique

UnitVI:Advanced Applications of Robots **[7]**

Pick and place Robot, Welding Robots, Assembly and mega-assembly Robots, Walking Robots, Climbing Robots ,Machinemounted Robots. Artificial Intelligence: Concept of A.I.,Role of A.I.in robotics.

TextBooks:

1. Deb S.R., “Robotics Technology and Flexible Automation ", Tata McGraw-Hill
2. Publishing Co., Ltd.
3. M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey, " Industrial Robotics Technology,
4. Programming and Applications & quot;, McGraw Hill Book Co.
4. Craig J.J., “Introduction to Robotics Mechanics and Control ", Addison-Wesley.
5. James G. Keramas, “Robot Technology Fundamentals”, CENGAGE Learning.

Reference Books

1. King Sun Fu, Gonzalez R.C., and Lee C.S.G., " Robotics: control, sensing, vision and intelligence”, McGraw-Hill Book Co.
2. Saeed B Niku, “Introduction to Robotics Analysis, Control, Application”. WILEY.
3. Mittal and Nagrath, “Robotics & Control”, Tata McGraw-Hill

411123:Elective III: Reliability Engineering

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks End-Sem:70Marks

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Pre-requisites:

Industrial Engineering and Management

Course Objectives:

Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability.
Introduce the principles and techniques of Reliability their practical uses in product and/or process design and monitoring
Illustrate the basic concepts and techniques of modern reliability engineering tools.

Course Outcomes:

Upon completion of this course the student will be able to:
Attain the basic techniques of quality improvement, fundamental knowledge of statistics and probability
Analyse system requirements in Industry
Describe different failure analysis techniques
Estimate product reliability
Optimize the requirements of product to achieve product efficiency

Unit 1: Probability Elements **[7]**

Probability concepts –Probabilities of events – Rules of Events– Failure Density and Distribution functions – Complementary Event – Binomial distribution – Rule of addition of Probabilities

Unit 2: Network Modelling **[7]**

Basic concepts – Evaluation of network Reliability / Unreliability – Series systems, Parallel systems, Series - Parallel systems, partially redundant systems – Types of redundancies - Evaluation of network Reliability / Unreliability using conditional probability method – Markov Chains Analysis – complete event tree and reduced event tree methods - Examples.

Unit 3: Failure Data Analysis and repairable system **[7]**

Basic concepts – Reliability functions f(t), F(t), R(t), h(t) – Relationship between these functions – Baths tubs curve – Exponential failure density and distribution functions - Expected value and standard deviation of Exponential distribution – Measures of reliability – MTTF, MTTR, MTBF – Evaluation of network reliability / Unreliability of simple Series, Parallel, Series-Parallel systems - Partially redundant systems - Evaluation of reliability measure – MTTF for series and parallel systems – Examples.

Unit 4: Fault Tree Analysis (FTA) **[7]**

General Procedure of the FTA- Qualitative Fault Tree Analysis- Quantitative Fault Tree Analysis Reliability Graph- Examples- Boolean Algebra.

Unit 5: Reliability Estimation **[7]**

Probability Distribution Functions - Discrete distributions - Uniform distribution, Marginal Distribution, Negative binomial distribution and Geometric distribution. Continuous distribution - Exponential distribution, double exponential, Rayleigh distribution, Weibull distribution, Gamma distribution, Beta distribution, Pareto distribution, Normal distribution and lognormal distribution - Sampling distribution - Correlation – The concept of Correlation, measuring correlation - Auto and cross correlation functions – Properties.

Unit 6: Reliability Optimization **[7]**

Partially redundant systems-Standby redundant systems-redundancy concepts-perfect switching imperfect switching-standby redundancy calculations-Component versus unit redundancy-Weakest Link Technique-Mixed Redundancy-Redundancy Optimization-Double Failures and Redundancy.

Text Book:

1. System Reliability Concepts by V. Sankar, Himalaya Publishing House.
2. Reliability Engineering by L. S. Srinath, East-West Press

Reference Books:

1. Reliability Evaluation of Engineering Systems by Roy Billinton and Ronald N. Allan, Reprinted in India B. S. Publications.
2. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill.
3. Reliability and Maintainability Engineering by Charles E. Ebeling, Tata McGraw Hill.
4. Probability concepts in Electric Power system - G.J.Anders - John wiley & sons.
5. Brend Bretsche, Reliability in Automotive and Mechanical Engineering, Springer Publications.

411123:Elective III: Micro Electro Mechanical Systems

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks End-Sem:70Marks

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Course Objectives:

Have a concept on the scope and recent development of the science and technology of micro- and nano-systems;

Gain the physical knowledge underlying the operation principles and design of micro and nano- systems;

Learn some typical or potentially applicable micro- and nano-systems at the frontier of the development of the field

Course Outcomes:

CO1: Ability to understand the operation of micro devices, micro systems and their applications

CO2 : Ability to design the micro devices, micro systems using the MEMS fabrication process.

CO3 : Gain a knowledge of basic approaches for various sensor design

CO4 : Gain a knowledge of basic approaches for various actuator design

CO5: Develop experience on micro/nano systems for photonics.

CO6 : Gain the technical knowledge required for computer-aided design, fabrication, analysis and characterization of nano-structured materials, micro- and nano-scale devices.

Unit I: Overview of MEMS and Microsystems

Overview of MEMS and Microsystems: MEMS and Microsystem, Typical MEMS and Microsystems Products, Evolution of Micro fabrication, Microsystems and Microelectronics, Multidisciplinary Nature of Microsystems, Miniaturization. Applications and Markets.

Unit II: Working Principles of Microsystems

Working Principles of Microsystems: Introduction, Micro sensors, Micro actuation, MEMS with Micro actuators, Micro accelerometers, Microfluidics.

Introduction, Molecular Theory of Matter and Inter-molecular Forces, Plasma Physics, Electrochemistry.

Unit III: Engineering Mechanics for Microsystems Design

Engineering Mechanics for Microsystems Design: Introduction, Static Bending of Thin Plates, Mechanical Vibration, Thermo mechanics, Fracture Mechanics, Thin Film Mechanicsand Overview on Finite Element Stress Analysis.

Unit IV: Scaling Laws in Miniaturization

Scaling Laws in Miniaturization: Introduction, Scaling in Geometry, Scaling in Rigid-Body Dynamics, Scaling in Electrostatic Forces, Scaling in Fluid Mechanics, Scaling in Heat Transfer.

Unit V: Overview of Micro manufacturing

Overview of Micro manufacturing: Introduction, Bulk Micro manufacturing, SurfaceMicromachining, The LIGA Process, Summary on Micro manufacturing.

Unit VI:Chemical and Bio Medical Micro Systems:

Sensing mechanism & principle, membrane-transducer materials, chem.-lab-on-a-chip (CLOC) chemoresistors, chemocapacitors, chemotransistors, electronic nose (E-nose), mass sensitive chemosensors, fluroscience detection, calorimetric spectroscopy.

Text Books

1. MEMS, Nitaigour Premchand Mahalik, TMH Publishing co.

Reference Books:

1. Hans H. Gatzen, Volker Saile, JurgLeuthold, Micro and Nano Fabrication: Tools and Processes, Springer, 2015.
2. Dilip Kumar Bhattacharya, Brajesh Kumar Kaushik, Microelectromechanical Systems (MEMS), Cenage Learning.
3. Foundation of MEMS, Chang Liu, Prentice Hall Ltd.
4. MEMS and NEMS, Sergey Edwrd Lyshevski, CRC Press, Indian Edition.
5. MEMS and Micro Systems: Design and Manufacture, Tai-Ran Hsu, TMH Publishers.
6. Introductory MEMS, Thomas M Adams, Richard A Layton, Springer International Publishers.

411124: Elective IV: Creative Product Design

TeachingScheme	CreditScheme	ExaminationScheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks End-Sem:70Marks

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Pre-requisites:

Basic manufacturing concepts , Basics of Engineering Graphics, Engineering Design, Engineering Graphics, Design of machine elements

Course objectives:

1. Understand the basic concepts of Design and Development, comparison between validation and verification, morphology of product design
2. Understand the technical and business consensus of Product Development
3. Understand Product development concept to product function
4. Understand product development in context of reverse engineering.
5. Develop an understanding of design for manufacture, assembly and environment
6. Get introduced to concept of PLM and PDM.

Outcomes:

After learning this subject, the student will be able to:

1. Understand the basic concepts of Design and Development, comparison between validation and verification, morphology of product design
2. Understand the technical and business consensus of Product Development
3. Understand Product development concept to product function
4. Understand product development in context of reverse engineering.
5. Develop an understanding of design for manufacture, assembly and environment
6. Get introduced to concept of PLM and PDM

Unit 1: Introduction to Product Design & Development [7]

Definition of product design, design by evolution and innovation, factors in product design, morphology of product design (seven phases), standardization, simplification and specialization in product design, modern approaches- concurrent design and quality function deployment, product development, product development versus product design, types of design and redesign, modern product development process, product development team and product development planning with reference to ISO standard, difference between product verification and production validation, introduction to prototyping, rapid prototyping methods.

Unit 2: Product Development - Technical and Business Concept [7]

Technology Forecasting and Technology S-Curve (Technology Stage), Mission Statement and Technical Questioning, Economic Analysis of Product, Customer Needs and Satisfaction, Customer Population and Market Segmentation, Customer Needs-Types and Models, Gathering Customer Needs Information, Analysis of Gathered Information.)

Unit 3: Product Development from Concept to Product Function **[7]**

Generating concepts, information gathering, and brainstorming, morphological analysis, concept selection design evaluation, estimation of technical feasibility, concept selection process, Pugh's concept, selection charts, numerical concept scoring, process of concept embodiment, system modeling, FMEA, functional modeling and decomposition, fast method, subtract and operate procedure, establishing system functionality, augmentation and aggregation

Unit 4: Product Development in the Context of Reverse Engineering **[7]**

Product Teardown Process, Tear Down Methods - Force Flow Diagrams, Measurement and Experimentation, Applications of Product Teardown, Benchmarking Approach and Detailed Procedure, Tools Used In Benchmarking - Indented Assembly Cost Analysis, Function -Form Diagrams, Trend Analysis, Setting Product Specifications, Introduction to Product Portfolio and Architecture.

Unit 5: Design for Manufacture, Assembly and Environment **[7]**

Design guidelines, design for manufacture, design for assembly, design for piece part production, manufacturing cost analysis, need and importance of design for environment, global, local and regional issues, basic DFE methods-guidelines and applications, life cycle assessment - basic method, weighed sum assessment method, life cycle assessment method, DFX, product testing, product validation, field trials, virtual trials, iterations

Unit 6 : Introduction to Product Life Cycle and Product Data Management **[7]**

Background, Overview, Need, Benefits, and Concept of Product Life Cycle, Components/Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement, Product Data and Product Workflow, The Link Between Product Data and Product Workflow, Different Phases of Product Life Cycle and corresponding technologies. Reliability concepts in product development.

Books:

1. A.K. Chitale; R.C. Gupta, “Product Design and Manufacturing” Prentice – HallIndia
2. Kevin Otto and Kristin Wood” Product Design: Techniques in Reverse Engineering and New Product Development”, Pearson Education Inc

411124 : Elective IV: Mechatronics

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks End-Sem:70Marks

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Course objectives:

1. Develop an understanding of the basic elements underlying mechatronic systems: measurement systems, sensors, actuators, microprocessors.
2. Understand how to interface electromechanical systems to microcontrollers.
3. Developing understanding of Process Control Computer Systems.
4. Gain hands-on experience with commonly used electronic test and measurement instrumentation

Course Outcomes:

The Student will be able to –

1. Define the Mechatronics systems, measurement and control system.
2. Understanding various sensors and transducers and their applications.
3. Describe the architecture, configuration and interfacing of Microprocessor.
4. Understand the Mini, Micro Computer process and Digital processes.
5. Analyze the logic of Programmable logic controllers and state their applications.
6. Illustrate the advanced applications in Mechatronic

Unit I: Control System: **[7]**

Introduction : Elements of control system, Types of control system, Microprocessors based controllers System Response : Amplitude linearity, phase linearity, distortion of signals, dynamic characteristics of systems, zero order systems, first order systems.

Signal Processing : Operational amplifiers, requirement for protection and filtering, comparators and Rheostat Bridge, ADC-DAC converter, multiplexes, Data acquisition using DAQ boards, principle of digital signal processing, principle of pulse modulation

Unit II: Digital Control Architectures **[7]**

Digital representations, combination logic & logic classes, timing diagrams, sequential logic, TTL and CMOS integrated circuits, integrated system circuit design.Microprocessors Basic structure of microcomputer, microprocessor and micro controller, programs using flow Charts orPseudo Codes

Unit III: Assembly Language & Input output Systems **[7]**

Use assembly language to write programmes dentify interface requirements, buffers, hand shaking and serial interfacing.

Function of synchronous communication, interface adapters.

Unit IV: Programmable logic controllers Basic structure of PLC, program of PLC, logic functions, latching and sequencing, Develop programs involving timers, internal relays, counters, shift registers. Sensors and Transducers, Performance or commonly used sensors, sensors used in measurements of Displacements, position proximity, velocity and motion, force, fluid pressure, liquid flow, Liquid level, temperature, stress and strain, vibration andacceleri1tIon, semiconductor, sensors and micro chemical devices.

Unit –IV Modeling and Analysis of Mechatronics System [7]

System modeling (Mechanical, Thermal and Fluid), Stability Analysis via identification of poles andzeros, Time Domain Analysis of System and estimation of Transient characteristics: % Overshoot,damping factor, damping frequency, Rise time, Frequency Domain Analysis of System and Estimation offrequency domain parameters such as Natural Frequency, Damping Frequency and Damping Factor.

Unit –V Sensors And Transducers [7]

Introduction - Performance Terminology - Displacement, Position and Proximity -Velocity and Motion – Fluid pressure - Temperature sensors - Light sensors - Selection of sensors - Signal processing – Servosystems Introduction to Mechatronics, Open and Closed loop control system, Block Diagram Algebra With respect to Types, Range, and Applications and limitations, Thermocouples, Thermistors and Resistance Temperature Detectors With respect to Construction, Working and Applications, Linear Variable Differential Transducer. With respect to Principle. Types, and Applications, Strain Gauges, Gauge Factor and Measurement of Strain With respect to construction, working and specifications Electromagnetic Flow meter. With respect to specifications and applications, Capacitive and Inductive Proximity sensors Angular Velocity measurement, Tacho generators, Rotary Encoders.

Unit –VI [7]

Basic structure of PLC, program of PLC, logic functions, latching and sequencing, Develop programs involving timers, internal relays, counters, shift registers. Sensors and Transducers, Performance or commonly used sensors, sensors used in measurements of Displacements, position proximity, velocity and motion, force, fluid pressure, liquid flow, Liquid level, temperature, stress and strain, vibration and acceleri1tIon, semiconductor, sensors and micro chemical devices**.**

Text Books:

1. B. H. Histard, D. G .Alciator, “Introduction to Mechatronics and Measurment Systems”, Tata McGraw
1. Hill Publication, ISBN 0-07-052970-8.
2. B. C. Kuo, “Automatic Control Systems”, prentice Hall, ISBN 0-87-692480-1.
3. D. Necsvlescu, “Mechatronics”, Pearson Education Pub. India Pvt. Ltd., ISBN 87- 78086726-X
4. C. D. Johnson, “Process Control Instrumentation Technology”, Prentice Hall of India Pvt.Ltd., New Delhi.
5. W. Bolton, “Mechatronics”, Pearson Education Asia New Delhi, ISBN 81-7808-3396.

References Books:

1. D. Shetty, R. Kolk, “Mechatronics System Design”, Thomson Books Pub., ISBN98-1240062-2.
2. B H Histand, D G Alciatore, “Introduction to Mechatronics and Measurement Systems”
3. Gopal, “Control systems”, Tata McGraw hill
4. Ramesh. Gaonkar, “Microprocessor”, Penram International Pub. Pvt. Ltd., ISBN 81-900828-09.
5. 8 Machining, Fundamentals and Recent Advances - Davim, J. Paulo (Ed.) 2nd Printing. 2008,

411124 : Elective IV: CAD/CAM

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks End-Sem:70Marks

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Course objectives:

1. The aim of this course is to develop an understanding of the basic principles underlying Computer aided tools used in engineering and to develop students' awareness in the application of CAD and CAM systems n the context of developing engineering products.
2. To provide the students with a foundation in computer aided design.
3. To produce knowledgeable users of CAD systems.
4. To understand the basic concept of Computer Integrated manufacturing and its Industrial applications using Modern Production Techniques.
5. To understand the concepts of CAD/CAM within the scope of CIM.

Outcomes:

After learning this subject, the student will be able to:

1. Describe the principles of Computer Aided Designing systems and the concepts of Transformation, Geometric modelling, solid modelling, and feature-based design modelling.
2. Create and design and manufacturing of mechanical parts using state of the art CAD System and Rapid Prototyping techniques.
3. Compare and distinguish the difference between the operation and programming of a CNC machine tool using manual programming and the operation and programming of CNC machine tool using CAM systems. Apply practices (manually) to develop the G-code program.
4. Understand the concepts of CAD/CAM within the scope of CIM.

Unit1: Introduction to CAD/CAM **[7]**

Introduction to CAD/CAM

Introduction: Trends in Modern Manufacturing, Product Cycle and CAD/CAM, Functional relationship, Elements of CAD Hardware.

Computer Graphics: Transformation- Introduction, Formulation,Translation, Rotation, Scaling, Reflection, Homogenous Representation, Concatenated Transformation, Inverse Transformations

Unit 2: Modelling Curves **[7]**

Introduction, Analytic Curves, Parametric representation, Line, Circle, Parabolas, Hyperbolas, Ellipses, Conics. Geometric continuity (C0, C1, C2) and Visual continuity (G0, G1,G2), Synthetic Curves, Hermite Cubic Spline, Bezier Curve, B-Spline Curve and NURB

Surface:- Introduction, Surface Representation, Analytic Surface, Synthetic Surfaces, Hermite bicubic Surface, Bezier surfaces, B-spline Surfaces, Coons Surface, Reverse Engineering

Solids:-Introduction, Geometry & Topology, Solid Representation, Boundary Representation, Constructive Solid Geometry, Sweeps, Solid Manipulations, Feature Based Modelling

Unit 3: **[7]**

Rapid Prototyping Importance and overview of Rapid Prototyping, Classification of Rapid Prototyping (RP) Process (FDM, LOM, SLA, SLS, Stereolithography etc.), Typical Process Chain for RP, Introduction to CAD and Data exchange format, data format details, conversion, validation, repairing, Part Slicing and Orientation and its importance, application and case studies.

Unit4: **[7]**

CIM Models

Introduction, ESPRIT – CIM OSA Model, The NIST – AMRF Hierarchical Model, The Siemens Model of CIM, The CIM model of Digital Equipment Corporation, IBM concept of CIM, Present Scenario.

NC Programming

Machine Tool Co-ordinate System, Machine zero, Job zero, Cutter Programming, Tool Offsets, Programming Steps, NC Programming Languages, G-codes and M-codes. Turning Center programming, Machining Center programming, Advance features of Controller..

Unit5: Design for Manufacture, Assembly and Environment **[7]**

Computer Integrated Manufacturing (CIM) Computer application in manufacturing, computer aided inspection and quality control. Computer integrated production management system, inventory material requirement planning, manufacturing resource planning, enterprise resource planning

Computer aided process planning (CAPP): Retrieval CAPP, generative CAPP and computer assisted shop floor control.

Unit6: Introduction to Product Life Cycle and Product Data Management **[7]**

Part Families, Part classification and coding, production flow analysis, Rank Order Clustering Algorithm, machine cell design and Cellular manufacturing.

Text Books:

1 Mikel P. Groover and Emory W. Zimmers: Computer Aided Design and Manufacturing, Prentice Hall.
2 T. Kundra, Rao P.M., Tiwari N.K. : Numerical Control and Computer Aided Manufacturing, Tata McGraw Hill
3 Nanua Singh: Systems Approach to Computer-Integrated Design and Manufacturing, John Wiley and Sons, Inc.
4 P. Radhakrishnan and Subramaniam: CAD / CAM / CIM, Wiley Eastern Ltd.
5 Venuvinod, PK., MA. W., Rapid Prortotyping – Laser Based and Other Technologies, Kluwer, 2004.

Reference Books:

1. Paul C. Bave: CAD Principles and Applications
2.Mikell P. Groover: Automation, Production systems & Computer Integrated
Manufacturing, Prentice Hall.

3.Ibrahim Zeid: Mastering in CAD-CAM, Tata McGraw Hill Publication.

4. Exposure of different types of manufacturing available today such as the Special manufacturing System, the Manufacturing Cell, and the Flexible Manufacturing System (FMS), basic concepts of Group Technology and Computer Aided Process Planning.

411124 : Elective IV: Data Analytics

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks End-Sem:70Marks

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Pre-requisites : Engineering Mathematics III, Numerical Techniques and Optimization Methods

Course objectives:

The objective is to provid basic understanding of data analysis using statistics and to use of computational tool on problems of applied nature.

Outcomes:

After learning this subject ,the student will be able to:

Effectively visualize and interpret the data

Apply predictive and prescriptive techniques for production engineering applications

Use data analysis for engineering applications through the powerful tools of data application

Unit1:Introduction to data analytics **[7]**

Significance & applications of data analytics, Data collection, data processing, data transformation, data integration, data visualization, basic statistics, inferential statistics

Unit2:Descriptive analytics **[7]**

Uni-variate/multi-variate statistics, bi-variate associations, correlations, covariance, analysis of variance (ANOVA)

Unit3:Predictive analytics **[7]**

Multiple regression, conjoint analysis, neural networks, data clustering, Data mining

Unit4:Classification techniques **[7]**

Linear classifiers, Quadratic classifiers, Support vector machines, Random forests.

Unit5:Prescriptiveanalytics **[7]**

Decision tree analysis, Expert system, principal component analysis, genetic algorithms

Unit6:Reinforcement learning **[7]**

1. Markov chain analysis, Monte Carlo simulation, Qlearning ,Stateaction reward stateaction(SARSA)learning

Books:

1. Acharya Seema and Chellappan, Big b Data and Analytics,Willey India Pvt .Ltd.(2015),ISBN:9788126554782

2. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, Willey India Pvt .Ltd.(2016),ISBN:978-1-118-87622-0
3. Michael Minelli, Michale Chambers, Ambiga Dhiraj, Big Data Analytics: Emerging Business Intelligence and analytics trends for today_s business, Willey India Pvt. Ltd.(2015)

411125 : Manufacturing Automation Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical:02hours/week	PR-TW:01	Termwork:25Marks Practical : 25 Marks

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Course Objectives:

To know the fluid power systems employed in manufacturing industry.

To learn how to design and analyse the fluid power systems required in automated· environment.

To be able to design the circuits for different operating requirements of an automated or· mechatronics system.

Syllabus Contents

1. Study & Design of basic hydraulic and pneumatic circuits: such as Standard ON-OFF and Pneumatic Latch.
2. Study & Design of Pneumatic or Hydraulic circuit for Two Push Button Control and Clamping of Work piece.
3. Study & Design of Pneumatic or Hydraulic circuit for material handling
4. Study & Experiments in 8051 Microcontroller & its applications in Production Engineering.
5. Study and Demonstration of Different Material Handling Equipment used in manufacturing Industry.
6. Study of Maintenance and Troubleshooting of Fluid Power Systems.
7. Study of Advance in Automation system (Unit 06)

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411126 : Operations Research Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical:02hours/week	PR-TW:01	Termwork:25Marks Practical : 25 Marks

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TermWork:

One exercise on each unit. At least one Computer Software Package such as MS-Excel,Lindo/Lingo, MATLAB,MS- Projects, Tora, AMPL etc. should be used. For each exercise along with manual solution of problems, any computer software package should be used to obtain the solution.

411127:Elective III: Additive Manufacturing

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:02hours/week	Practical/Oral:01	Oral:25Marks

Course Objective.

1Students will be able to Identify and describe the function of different parts of the 3D printer.
2. Students will be able to: Use the simulator & assemble the different parts of the 3D printer.
3. Students will be able to: Realize the operation of the 3D printer for different parameters given by the student and can check the effect of the different parameter on the performance of the printer.
4. Students will be able to: Build a given 3D printer by using the different parts available with the students. This will help them to learn the assembly without actually destructing the parts.
5. Students will be able to: answer the questions related to part functioning and the assembly of the 3D printer

Laboratory Work.

A).In the Additive Manufacturing Lab work total six Assignments will be performed by the students one Assignment on Each unit as Part of Term work.
B) Following Experiments will be conducted on Virtual Lab. 3D Printing Virtual Simulation Lab
1. FDM Anatomy of 3D Printer Machine-https://3dp-dei.vlabs.ac.in/exp/simulation-anatomy-fdm/
2. Cartesian 3D Printer Machine-https://3dp-dei.vlabs.ac.in/exp/simulation-cartesian-system/
3. Polar 3D Printing machinehttps://3dp-dei.vlabs.ac.in/exp/simulation-of-polar-machine/
4. Delta 3D Printing machine-https://3dp-dei.vlabs.ac.in/exp/simulation-of-delta-machine/
5. Simulation of Stereolithography Process-https://3dp-dei.vlabs.ac.in/exp/simulation-stereolithography-process/
6. Simulation of Fused Deposition Modelling (FDM) Process-https://3dp-dei.vlabs.ac.in/exp/simulation-modelling-process/
7. Simulation of Selective Laser Sintering (Non-Metal) Process-https://3dp-dei.vlabs.ac.in/exp/simulation-laser-sintering-nonmetal/
8. Simulation of Selective Laser Sintering (Metal) Process-https://3dp-dei.vlabs.ac.in/exp/simulation-laser-sintering-metal/
9. Simulation of Laminated object manufacturing Process-https://3dp-dei.vlabs.ac.in/exp/simulation-laminated-object/
10. Simulation of Powder Binding / Jetting Process-https://3dp-dei.vlabs.ac.in/exp/simulation-powder-binding/
11. Simulation of Post-processing in Additive manufacturing-https://3dp-dei.vlabs.ac.in/exp/simulation-post-processing/
12. Simulation of Pre-processing in Additive manufacturing-https://3dp-dei.vlabs.ac.in/exp/simulation-additive-manufacturing/

411127:Elective III: Industrial Robotics Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:02hours/week	Practical/Oral:01	Oral:25Marks

Experiment Should Consist of:-

1. To Study the Specifications of Industrial Robot.
2. Demonstration of Pen & Writing Application of Robot
3. Numerical Assignment on Robotic Grippers.
4. Demonstration of Suction Cup & Gripping Application of the Robot
5. To Study Laser Engraving Application of the Robot
6. Assignment on Forward & Inverse Kinematics in Robotics.
7. Demonstration of 3D Printing Application of Robot.
8. Assignment on Cobot (Case Study Based)

411127: Elective III: Reliability Engineering Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:02hours/week	Practical/Oral:01	Oral:25Marks

Term Work will be based on following topics:

1. Characteristics of Binomial and Poisson distributions
2. Determination of MTTF for series and parallel systems
3. Characteristics of Exponential and Weibull distributions
4. Evaluation of basic probability indices for series systems
5. Evaluation of basic probability indices for parallel systems
6. Markov Chains Analysis using failure mode software package
7. Fault Tree Analysis using failure mode software package
8. Case study on Industrial Application

411127: Elective III: Micro-Electro mechanical systems Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:02hours/week	Practical/Oral:01	Oral:25Marks

Conduct any six labs/assignments

1. Lab on Static Bending of Thin Plates, Mechanical Vibration,
2. LAB ON Hydromechanics, Fracture Mechanics, Thin Film Mechanics,
3. LAB ON Finite Element Stress Analysis.
4. Demonstration on Bulk Micromanufacturing,
5. Demonstration on Surface Micromachining,
6. Demonstration on The LIGA Process, Demonstration on Micromanufacturing.
7. MEMS with Micro actuators,
8. Case study on Micro accelerometers, Microfluidics.
9. Case study on Mechanical Properties of MEMS Material

Textbook/ Textbooks

(1) Smart Material sand Structures- M.V. Gandhiand B. So Thompson, Chapmanand Hall, London; NewYork,1992.

(2) Smart Structures and Materials- B. Culshaw, Artech House, Boston,1996. (3) Smart Structures: Analysis and Design-A.V.Srinivasan, Cambridge University Press, Cambridge, NewYork,2001.

Reference Books

(1) Piezoelectric Sensories : Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002

(2) Hand book of Giant Magneto strictive Materials-G.Engdahl, Academic Press, San Diego,Calif.;London,2000

411128: Elective IV: Creative Product Design

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:02hours/week	Practical/Oral:01	Oral:25Marks

Syllabus Contents:

Any six assignments based on the above syllabus (One from each unit)

411128: Elective IV: Mechatronics

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:02hours/week	Practical/Oral:01	Oral:25Marks

List of Experimentation Work.

1. Program on microcontroller / microcontroller simulator.
2. Ladder diagram and programming using PLC
3. Study of process control loop including sensors, controllers and final control elements/actuators
4. Study of ADC/DAC used in Data Acquisition System (DAQ)
5. Measurement of speed and temperature
6. Study of displacement level and pressure control.

411128: Elective IV: CAD/CAM

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:02hours/week	Practical/Oral:01	Oral:25Marks

Courseobjectives:

- To understand the basic procedure required to develop the solid model using solid modeler.
- To understand the concept of Rapid Prototyping Techniques using Additive Manufacturing Technology. Actual use of FDM Technology Machines to study the additive manufacturing technology and its applications.
- To understand the concept of N.C machines and part programming, Simulation of tool path and generation of part program using CAM package.
- To provide the fundamental concepts of the theory of the finite element method
- To develop proficiency in the application of the finite element method (modeling, analysis and interpretation of results) to realistic engineering problems based on structural analysis through the use of FEA packages.
- To demonstrate the ability to create models for trusses, frames, plate structures, machine parts, and components using ANSYS software.

Outcomes:

After learning this subject, the student will be able to:

1. Understand how CAD technology can be leveraged in the design & manufacturing process
2. Understand and use the advance technologies like Additive Manufacturing Technology to solve complex real life problems
3. Compare and distinguish the difference between the operation and programming of a CNC machine tool using manual programming and the operation and programming of CNC machine tool using CAM systems. Apply practices (manually) to develop the G-code program
4. Understand the concept of FEA and its requirement in design and manufacturing phase.
5. Evaluate and interpret FEA analysis results for design and evaluation purposes to solve complex real life problems
6. Develop a basic understanding of the limitations of the FE method and understand the possible error

Syllabus Contents:

1. To Study of Solid Modeler and Modeling of Simple machine parts
2. Study of Rapid Prototyping Techniques by Using Additive Manufacturing Technologies as FDM Technology
3. To study Simulation of cutting/milling operations using CAM packages
4. Introduction to FEA, Advantages & Disadvantages of FEA & its Applications, What is FEA, Functional Approximation method, Finite Difference Method, Steps involved in FEA, Stiffness matrix & its properties, Derivation of Stiffness matrix, Types of Elements.
5. Introduction to ANSYS, ANSYS Interface & Environments, Problem solving methodology in ANSYS.
6. Analysis of various problems using ANSYS software.

411128: Elective IV: Data Analytics

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:02hours/week	Practical/Oral:01	Oral:25Marks

For The Laboratory work of Data Analytics one Assignment on each unit completed by the students.One case study in Data Analytics will completed by the students. Also demonstration of V –Lab for the students.

411129: MOOCs

Teaching Scheme	Credit Scheme	Examination Scheme
NA	Theory:02	TW:50Marks

Students should complete any one of the following MOOCs courses: The assessment will be either based on the online score obtained in that course or by giving the assignments on the course chosen by the student.

1. Developing Soft Skills and personality
2. Enhancing Soft Skills and personality
3. Spearing Effectively 8 Weeks
4. Introduction to Industry 4.0 and Industrial Internet of Things
5. Emotional Intelligence.
6. Patent Law for engineers and Scientist.

411130: Mini Project

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:04hours/week	Tern Work:02	Term Work:50Marks

Guidelines:

1. Mini Project can be an individual or a group activity depending on the depth and scope of the topic.
2. The project work can be any of the form given below :

a) Making physical working models, prototypes, scaled models, of a concept machine.
b) Making virtual / CAD models of a sufficiently complex machines / concepts.
c) Making study, modeling, analysis, programming and simulation of a system / machine / operation / process.
d) Making study / teaching modules of a sufficiently complex topic for pedagogy purposes.

3. Group formation, discussion with faculty advisor, formation of the Semester Mini Project statement, resource requirement, if any should be carried out in the earlier part of the Semester.
4. The students are expected to utilize the laboratory resources before or after their contact hours as per the prescribed module.
5. A complete Assembly and Details drawings of the project should be submitted along with a detailed project report, where applicable
6. A Detailed Background / field / literature survey, related to the topic must be made and presented in the report
7. Review – I: during Mid Semester Examination (Compulsory) as per the Academic Calendar.
8. Review – II : The last week of the Semester . (Optional)
9. For poor performing students identified by the examiners, a second review to be taken.

Evaluation Scheme :

1. Attendance during Semester – 10 marks
2. Regularity in project work execution and reporting – 10 marks
3. Relevance of Mini-Project topic – 10 marks
4. Timely Abstract submission – 10 marks
5. Literature review – 10 marks
6. Technical contents /skills / Knowledge – 10 marks
7. Presentation – 25 marks 8. Question & answer Session – 15 mark

Course Outcomes:

1. Students will be able to apply basic principles and concepts for development of working model
2. Students will be able to work in groups and participate in group discussions
3. Students will be able to demonstrate and present the working model
4. Student will be able to develop skills of technical report writing and presentation

Important Note: It is mandatory for every student to undertake a Mini project. Mini project shall be agroup activity. A group shall consist of maximum five students. Final evaluation shall include 30%weight age to mini project

411131: Audit Course 7: Human Rights

After completing the course the students will be able to:

1. Understand the importance and different approaches to Humanrights
2. Understand the different mechanisms of United Nations to ensure and protect the Human Rights
3. Understand the different Constitutional provisions and legislations to protect Human Rights in India
4. Analysethe functions of NHRC ,Judiciary and PILfor protecting Human Rights in India
5. Examine the challenges to Human Rights of different vulnerable sections

Unit I: Human Rights

Meaning, Evolution and Importance, Approaches: Western, Marxian, Feminist and Third World

Unit II: Uno and Human Rights

Universal Declaration of Human Rights, International Covenants on Civil and Political Rights (ICCPR), International Covenant on Social Economic and Cultural Rights (ICSECR), The Office of the United Nations High Commissioners for Human Rights(UNHCHR)

Unit III: Human Rights in India

Constitutional Provisions- Fundamental Rights, Directive Principles of State Policy, Some important Legislations- 1) Protection of Civil Rights Act-1955, 2) Prevention of Atrocities (SC and ST) Act 1989, 3) Sexual Harassment of Women at workplace (Prevention, Prohibition and Redressal) Act, 2013, 4) The Rights of Persons with Disabilities Act-2016, 5) Right to information Act 2005. Agencies Protecting Human Rights; Judiciary, Public Interest Litigation, National Human Rights Commission and Media

Unit IV: Challenges to Human Rights

Human Rights Violations against Women, Children, Other marginalised sections like Minorities, Dalits, Adivasis and Women, Refugees

Reference Books:

1 Andrew Clapham, Human Rights: A Very Short Introduction, Oxford University Press, New York,
20072DarrenJOByrne,(ed),HumanRights:AnIntroduction,Pearson,NewDelhi,2004
3ChiranjeeviNirmal,HumanRightsinIndia,OxfordUniversityPress,NewDelhi,1997.
4PavithranKS,(ed),HumanRightsinIndia:DiscourseandContentions,Gyanbooks,NewDelhi,2018
5UjwalKumarSingh,(ed),HumanRightsandpeace:Ideas,Laws,InstitutionsandMovements,Sage,NewDelhi,
2009

411132: Industrial In-plant Training

Teaching Scheme	Examination Scheme
2Contacthours/Week	TermWork:150 Marks
	Oral:150 Marks
	Credit : 12

The student shall undergo industrial training for the period of 6months in an industrial establishment and spend about 8 weeks for observational training and solving minimum three assignments given by the organization. The remaining period shall be utilized for project (411128). Students are expected to analyze the problems systematically and offer suggestion/concluding remarks.

Training:

The student shall under go training program prepared by the industry in following manufacturing and functional area.
Plant Engineering: Plant Layout ,Plant Maintenance, Housekeeping ,Material Handling& safety.
Production Planning And Control ,Quality Assurance.
Material Management: Inventory Control, Vendor Development, Vendor Rating, Raw Material and Finished Goods stores.
Industrial Engineering: Method Study, Work Measurement, Ergonomics and Productivity Improvement Technique.
Costing and Cost Control.
Management Information System(M.I.S.).
Incentive Schemes, Labor Laws. Factory Acts.
Import Export Procedures.
Machine/ Process Diagnosis.
Quality Assurance, Quality Improvement.
Improvement in tool layout, tool selection machine selection.
Maintenance of machines,house keeping, safety precautions.
Computer based information study for stores, purchase wastage of material, In process material planning and scheduling, assembly of storage of finish product dispatch.
Incentive schemes, labor laws, factory laws.
The students shall submit a detailed report on his training and assignments.

411133: Project

Teaching Scheme	Examination Scheme : 2Contacthours/Week TermWork:100 Marks Oral: 150 Marks Credit : 3

The student shall submit a report on project, suggested by industry where he is undergoing for In plant training. The scope of the project shall be such as to complete it with in the time schedule.

Project maybe of the following types:
Manufacturing / Fabrication of a prototype machine including selection, concept Design, material selection, manufacturing the components, assembly of components, Testing and performance evolution.
Improvement of existing machine/ equipment/ process.
Design and Fabrication of Jigs and Fixtures, dies, tools, special purpose equipment, and inspection gauges, measuring instruments for machine tools.
Computer aided design, analysis of components such as stress analysis.
Problem relate dto productivity improvements.
Problem related to value engineering.
Problem related to material handling system.
Energy audit of organization, industrial evaluation of machine devices.
Design of a testrig for performance evaluation of machine devices.
Product design and development
Detailed cost estimation of product.
Analysis, evaluation and experimental verification of any engineering problem encountered.
Quality system and management, Total quality management.
Quality improvements In-process Inspection Online gauging.
Low cost Automation, Computer aided automation in Manufacturing.
Time and Motion Study, Job evaluation.
Safety.
Management Information System.
Market analysis in conjunction with production, planning and control.
Any other relevant topic.

The student shall submit a detailed report based on the project work. Format of the project report should be as follows:

Paper: The Projectreportshouldbetypes.printedonwhitepaperofA-4size.
Typing: The typing shall be with single spacing and on one side of the paper.
Binding: The Industrial Inplant Report should be submitted with front and back cover in black hand bound, with golden embossing.
Margins: Left- 1.25",Right- 1".Top&Bottom1".

Sequence of Pages:
Title page
Certificate form Institute
Completion Certificate form Industry, if sponsored.
Acknowledgement
Abstract
Index
Nomenclature & Symbols
Actual Content
Conclusion
References.
Front cover:
The front cover shall have the following details in block capitals
Title at the top.
Name of the candidate in the centre, and
Name of the Institute, Name of Industry ,if sponsored and the year of submissionon separate lines, at the bottom.
Blank sheets : No blank sheets be left anywhere in the report.
Project Completion Certificate:
The approval sheet follow the title sheet and shall be as shown with proper spacing.

CERTIFICATE
This is to certify that Mr ./Ms has carried out a Project entitled (Name) during the course of his(Name of Project) training at..... (Name of Industry) in partial fulfilment of the requirement of the B.E. Production Sandwich Course of University of Pune at during the academic Year..... (Name of Industry)
Date: (Guide)
Place:

(Examiner) (Head of Department)

Two copies of Industrial Implant Training & Project shall be submitted to the college. The student shall present their project before the examiners. The oral examination shall be based on the term work submitted, and jointly conducted by an internal and an external examiner from industry.

411134: Supply Chain Management – (Elective V – I)

Lectures: Self-Study	Theory:03	In-Sem:30Marks End -Sem:70Marks

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UnitI: Introduction Supply Chain Management(8)
Building a Strategic frame work to Analyze Supply Chains: Understanding the supply chain, supply chain performance, Supply chain drivers & obstacles.

UnitII: Planning Demand & Supply in Supply Chains:(8)
Demand forecasting in supply chain, aggregate planning in supply chain, planning demand & supply in supply chains.

UnitIII: Planning & Managing Inventories in a Supply in Supply chains:(8)
Managing economies of scale in a supply chain: cycle inventory, managing uncertainty in supply chain: safety inventory ,determining optimal level of product availability.

Unit IV: Design consideration in Supply Chain(8)
Transportation, Network Design,& Information technology in a supply chain: Transportation In supply chain, facility decisions: network design in a supply chain ,information technology in a supply chain.

UnitV: Supply Chain Coordination(8)
Coordinating in a Supply Chain & role of E- Business: Coordination in a supply chain, E- business & the supply chain.

UnitVI: Financial consideration in Supply Chain(8)
Financial factors Influencing Supply Chain Decisions: Financial evaluation of supply chain decisions, the impact of financial factors on supply chain decisions, evaluating supply chain decisions using decision trees,

Text Books:

1. Sunil Chopra & Peter Meindl, "*Supply Chain Management: Strategy, Planning, & Operation*", Addison WesleyLongman.
2. J.Vanweela,"*Purchasing&Supply Chain Management* " Cengage learning (Nov2004) ISBN 1844800245

Referencebooks:

1. R.H.Ballou,"*Supply Chain Management*" Pearson [2007] ISBN8131705846 B.E.ProductionEngineering–S/W 2008ProposedSyllabus
2. Simchi-Levi, Kaminsky, "*Designing and Managing the Supply Chain, Concepts Strategies and Case Studies*", 2nd edition, Tata Mc Graw Hill, ISBN 0-07-058666-7

3. R.Monczka,"*Purchasing&Supply ChainManagement*" Cengage learning business Press., ISBN140801744X

411134:Plant Engineering And Maintenance (Elective V – II)

Lectures:Self-Study	Theory:03	In-Sem:30Marks End -Sem:70Marks

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UNITI: Organisation of Plant Engineering:(8)

Principles of Plant management functions .Classification of maintenance work-Routine maintenance, emergency work, service work, preventive maintenance. Project work, Corrective work, Assessment of maintenance work. Performance and productivity measurement; problem solving techniques. Statistical processes.Parato chart.Man power planning and training for maintenance and safety staff.

UNITII: Plant Facilities and Layout Planning:(8)

Basic Plant facilities, (a) Building: Types of Building structures, Ventilation and lighting, Roads and parking. (b)Electrical power generation, distributions, utilization, stand by units. (c) Heating, ventilation and Air conditioning. (d)Water supply, Purification, use and disposal. (e) Sanitation. (f) Planning and estimation of auxiliary services, such as water,steam,compressed air.

Layout of facilities-Types of layouts, selection of layout. Group technology aspect. P. Q. Analysis, PQRST analysis, material flow, REL charts ,space requirements, space diagram .Use of computer for optimization of layouts.

UNITIII: Maintenance Management Practice:(8)

Various types of maintenance, breakdown, preventive, periodic or predictive ,condition based maintenance as predictive preventive maintenance. Online or off-line, concept of health as well as usage monitoring. Quantitative decision making for selection of maintenance system & management classification of material, MICLASS, CUSDD, Software for Classification and Coding. Maintenance problems occurring in product and process type industries and Power plants and their management.

Spare Parts Management-Simulation and Software needed for spare parts management and inventory planning.

UNITIV: Preventive Maintenance and Life Cycle Costing:(8)

Periodic Preventive Management-Scheduled maintenance and period for P.M. Life cycle cost taking into consideration maintenance, reliability, hazard function etc. Life cycle costing: Rigorous models, mathematical formulation etc.

UNITV: Plant Safety issues and Energy conservation:(8)

Plant safety-fire protection and prevention, safety against mechanical hazards, chemical hazards, accident prevention practices and codes. Pollution control Waste disposal, existing limiting norms.Recycling of waste.Energy conservation, management and audit. Material handling equipments.

UNITVI: Advanced topics in Maintenance Engineering:(8)

Condition based maintenance, using Vibration Signature, SOAP, ferrography, hot ferrography, Infra Red Camera, fluorescent dye, Particle Analyzer sand other diagnostic techniques. Reliability Centered

Maintenance. Total Productive Maintenance: Organization, merits and demerits, Terotechnology and its influence on plant engineering and maintenance, specific application areas, Overall effectiveness of equipment (OEE). RAM analysis: Inherent Availability, Operational Availability,etc.

TextBooks:

1. K.Gupta,"*Terotechnology &Reliability Engineering* ",McMillanCo.
2. SushikumarSrivastava,"*Industrial Maintenance Management*",S . Chandand Co. Ltd. , NewDelhi.
3. R.C.Rosaler-HandbookofPlantEngineering-McGrawHill.ISBN0070521646
4. Referencebooks:
5. B.Bhadury and S.K. Basu, "*Terotechnology: Reliability Engineering and Maintenance Management* ",Asian Books,NewDelhi2002.
    A. K.S.Jardine,"*Maintenance,Replacement&Reliability*" HMSO,London.
6. R.A.Collacatt,"*MechanicalfaultDiagnosisandConditionMonitoring*",ChapmanandHallLtd.ISBN0412129302
7. Higgin-Handbook of Maintenance Engineering-McGrawHill.
8. Rudenko-Material,Handling equipment-MIR:-Publication.
9. JacobFruchlboum-BulkMaterialHandling,Handbook;CBSPublisher&distributor,ISBN8123905416
10. H.P.Garg-IndustrialMaintenance,S.ChandandCo.NewDelhi,ISBN8121901685
11. EdwardSrivastava-Maintenance Management.

411134: Industrial Relations & Human Resource Management (Elective V – III)

Lectures: Self-Study	Theory:03	In-Sem:30Marks End -Sem:70Marks

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UnitI: Industrial Relations(8)

Status labour relations, cause and effects of strained relations, organized labour and Trade Union ,History of Indian Trade Union movement , Role of Trade Union, Responsibilities and functions of trade unions, Collective bargaining, its effects on industrial relations, Financial and nonfinancial incevetives for improving industrial relations.

UnitII:Human Resources(4)

Management - Introduction and Importance - Evolution - Difference between Personnel Management and HRM - RoleofHRManager-StructureofHRDepartment-DutiesandresponsibilitiesofHRManager

HRD Systems:(4)

Evolution-Goals-Elementsandtheirinterrelationship-HRStrategies-HRStrategiesandOrganizationalStrategies.

UnitIII:Manpower Planning(4)

Objectives-Estimating man power requirement-Recruitment and selection process–Main resourcesofrecruitment-AssessmentDevices-Retentionofmanpower– Succession Planning

MeritRating:(4)

Promotions- Transfers-JobDescription-JobEvaluation-JobEnlargement–JobEnrichment-JobRotation

UnitIV:Training and Development(8)

TrainingProcessandMethodology-Needandobjectives-TrainingProcedure-MethodsofTraining-ToolsandAids-EvaluationofTrainingProgrammes

UnitV:Performance Appraisal Management System(8)

Definition, Ethics and Concepts of Performance Management-Different methods of Performance Appraisal-Rating Errors

UnitVI: Retirement/Separation(8)

Kinds of Retirement - Resignation, Discharge, Dismissal, Suspension, Retirement, Layoff, Voluntary Retirement /Separation Schemes, Golden handshake. Role of HRD in developing Industrial Relations - Concept – Industrial Democracy-Industrial Peace

TextBooks:

1. GarryDessler,"*HumanResourceManagement*,Pearson",ISBN8131725383
2. R.S.Dwiwedi, Managing Human Resources.

Referencebooks:

1. C.B.Mamoria,"*PersonnelManagement"*,ISBN5000000055
2. B.P.Michael,Human Resource Management.
3. Dr.P.C.PardeshiHuman Resource Management.
4. Mirza&Saiyadin,"*Human Resources Management*",Tata McGraw Hill Company.
5. Arun Monappa,Managing Human Resources.

411134: Marketing Management (Elective V – IV)

Lectures:Self-Study	Theory:03	In-Sem:30Marks End -Sem:70Marks

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UnitI:Introduction to Marketing Management(8)
Marketing philosophy of business, an industrial marketing perspective, Understanding and monitoring the environment

UnitII:Customer Behavior(8)
Understanding consumer's decision processes, analyzing Consumer Behavior, perspectives of organizational buyers in industrial markets

UnitIII:Market Segmentation(8)
Gatheringmarketinginformation,segmentingmarketsandpositioningproducts,formulatingmarketingstrategies,planningmarketingprogrammes,managingproducts

UnitIV:Marketing Organization for New Product(8)
Developing newproducts, marketing intermediaries, managing market logistics, Pricetheories, Establishing and managing prices, designing and managing product promotions

UnitV:Sales Management(8)
Managing sales force and sales territories,Services marketing, marketing and technological innovations, Non-profit and social marketing

UnitVI:Market Research(8)
Marketing research and its importance, scope,structure and methods,role of quantitative techniques and tools in marketing research

TextBooks:

1. Philip Kotler,"*Marketing Management*",PrenticeHall, ISBN0130122173
2. V.S.RamaswamyandS.Namakumari,"*MarketingManagement,Macmillan*",ISBN0333937198
3. Lilien&Kotler&Moorthy,"*MarketingModels*",PrenticeHall,ISBN8120314751

Referencebooks:

1. W.J.Stanton,"*FundamentalsofMarketing"*,McGrawHill1998
2. PhilipKotler and GaryArmstrong,Principles of Marketing9thEdition-
3. Boveeand JohnThill, Marketing
4. R.Srinivas,"*CaseStudiesinMarketing-Indiancontext",*4thEditionPhiLearninng,ISBN8120335430

411135:Elective V – Term Work

Teaching Scheme

Examination Scheme :Self-Study
TermWork:50 Marks
Credit:1

Term Work:

Analysis assignments based on the respective Elective V syllabus (One from each unit)

411136: Seminar 2

Teaching Scheme	Examination Scheme
2Contacthours/Week	Oral:25 Marks
	Termwork:25 Marks
	Credit: 1

Seminar 2 shall be based on deep study of any topic related to Production Engineering; Format of there port shall be as follows:

Paper: The Seminar 2 report should be typed/printed on white paper of *A-4*size.
Typing: The typing shall be with single spacing and on oneside of the paper.
Binding The Seminar 2 report should be submitted with front and back cover of card paper neatly cut to size and spiral bound together with the text.

MarginsLeft- 1.25",right-1",Top&Bottom1".

Sequence of Pages:

- Title Page
- Report Approval Sheet
- Acknowledgement
- Abstract
- Contents
- Nomenclature & Symbols Actual Content
- Conclusion
- References
- Front cover:
- The front cover shall have the following details in block capitals..
- Title at the top.
- Name of the candidate in the centre ,and
- Name of the Institute and the year of submission on separate lines ,at bottom.
- Blank Sheets
- No blank sheet be left any where in the report.
- Title sheet
- The title sheet shall be the first sheet and shall contain following details with proper spacing.
- Seminar on(TITLE)

By(Name)
{Examination No.(Roll No.)}Under Guidance of

Report Approval sheet:
The approval sheet shall follow the title sheet and shall be as shown with proper spacing. This is to certify that Seminar entitled……

Submitted by……..Examination No…….
Is approved for the award of degree of B.E.(Production Engineering Sandwich)of University of Pune, Pune during the academic year……
Date: (Guide)
(Examiner) (Head of Department)
The format of the Seminar:
The report shall be presented in the form of a Seminar.

The introduction should be followed by the Literature survey.
Report of any analytical or experimental work done should follow the literature survey.
Figures should be drawn on separate sheets and inserted on the page on which the text is typed. The figures are drawn in either permanent black, ink or printed on paper .The figures should be numbered.
Tables shall be typed in text.
A separate sheet may be used, if necessary. The table shall be numbered.
Mathematical portion of the text shall be preferably. If this is not possible, it should be written in permanent black ink, Lengthy Mathematical derivations shall not be included. Only the important steps and expressions shall be given.
Discussions and conclusions shall for the last paragraph of the text.

References
The references shall form the last section and shall be followed by 'Appendix' if any. They should contain list of works (Papers, Books, etc.) referred to in the body of the text. The numbering shall be done in numerals (e.g. 1, 2,) indicated as superscript along with the author's name in the text. For any paper, the name of journals, the volume number, the page number and the year of publication in parenthesis.
In case of references *from* journals and books in languages other than English the titles of the journal or book shall be translated into Latin script. For any book the information shall contain the names of authors, title, publisher and the year of publication in parenthesis. For papers and books with joint authorship the names of all the authors shall be introduced in the same order. The author's
Names shall be last name followed by initials.
The total number of typed pages excluding the cover should be from 15 to *20* only. All the pages should be numbered.
Two copies of report shall be submitted to the college. The students shall present the Paper before the examiners.

411137: Audit Course 8: Leadership Excellence

UnitI:Team working and collaborations:

Understanding team and team dynamics, leading teams, analysing teams and team performance, collaborative team. Characteristics of Successful Team, Stages in team Development, Team Structure,Teamleadership,Assessingeffectiveteam,CrossfunctionalCollaboration:Introduction,definitioncross functional team work, Why use cross functional teams, Desired outcomes and team types, Towards a model of cross functional team type

UnitII:Meeting and Email Etiquettes:

Managing a Meeting: Meeting agenda, Meeting logistics, Minute taking, protocols during the meeting;Dutiesofthechairperson,Groundrulesforconductingmeeting;*EffectiveMeetingStrategies:*Preparingfor the meeting, Conducting the meeting, Evaluating the meeting, Rules for meetings, Codes of Conduct while attending Meetings, Tips for good meeting etiquette;

Business Card Etiquette: Carrying business cards, exchanging business cards, Receiving and storing business cards;

E-Mail Etiquette: Significance of Netiquette, Enforcement of email etiquettes in the organization, E-mail: Way of professional communication, Basic Email Etiquettes: Proper Grammar, Spelling, Punctuation Styling and Formatting, Body of Email, Response, Privacy; Contents of email, Best practices of writing emails, Controlling contents of email

UnitIII:Time Management

Time Management strategies: Daily planning, Prioritization of Tasks, Use of Time Management Tools, Determination of productive Times, Remove Distractions, Use of a Timer, Splitting Large Projects into Pieces, Delegation of Work;

Time management tools: Time tracking software, To-Do-list, project management software, communication tools (skype, slack, zoom), Apps helpful in creating good habits, Managing interruptions, managing procrastination;

Time management skills: Prioritizing, Delegation, Decision-making, Goal setting, Multitasking, Problem solving, Strategic thinking, Scheduling.

Reference Books:

1. Michael Egan(2004)Email Etiquette,NewLinePublishing,ISBN:9781844811182
2. Marc Mancini(2003)Time Management,McGrawHill,ISBN:978-0071406109
3. Alison Hardingham(1998) Working in Teams,CIPDPublishing,ISBN:9780852927670