Savitribai Phule Pune University

Faculty of Science & Technology

Curriculum for

B. E. (Production)

2019 Course

(with effect from June 2022)

Savitribai Phule Pune University, Pune
BE (Production 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
411081(A)	Automation and Control Engineering	3			30	70				100	3			3
411082(A)	Operations Research	3			30	70				100	3			3
411083(A)	Elective III	3			30	70				100	3			3
411084(A)	Elective IV	3			30	70				100	3			3
411081(B)	Automation and Control Engineering Lab		2				25	25		50		1		1
411082(B)	Operations Research Lab		2				25	25		50		1		1
411083(B)	Elective III Lab		2						25	25		1		1
411084(B)	Elective IV Lab		2						25	25		1		1
411085	MOOCs						50			50		2		2
411086	Project stage 1			4			50		50	100			2	2
411087	Mandatory Audit Course 7	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**12**	**8**	**4**	**120**	**280**	**150**	**50**	**100**	**700**	**12**	**6**	**2**	**20**

Elective III

1. Simulation, Modeling and Digital Twin
2. Total Quality management
3. Artificial Intelligence in Manufacturing
4. World Class Manufacturing

Elective IV

1. Plant Maintenance and industrial safety
2. Surface Engineering
3. Reverse Engineering
4. Entrepreneurship and Innovations

Savitribai Phule Pune University, Pune
BE (Production Engineering)
2019 Course
(With effect from Academic Year 2020-21)

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	PR	Project	Total
411088(A)	Computer Integrated Design and Manufacturing	3			30	70				100	3			3
411089(A)	Industrial robotics	3			30	70				100	3			3
411090	Elective V	3			30	70				100	3			3
411091	Elective VI	3			30	70				100	3			3
411088(B)	Computer Integrated Design and Manufacturing Lab		2				25	50		75		1		1
411089(B)	Industrial robotics Lab		2				25		50	75		1		1
411092	Project stage 2			12			100	50		150			6	6
411093	Mandatory Audit Course 8	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**12**	**4**	**12**	**120**	**280**	**150**	**100**	**50**	**700**	**12**	**2**	**6**	**20**

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

Elective V
1. E-Mobilty in Automobile
2. Smart Manufacturing
3. Manufacturing System design
4. Ergonomics and Work Management

Elective VI
1. Facility Planning
2. Additive Manufacturing
3. Reliability Engineering
4. Data Analytics

411081(A): Automation & Control Engineering

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

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Pre-requisites: Electrical & Electronics Engineering, Design of machine elements, Heat and fluid engineering

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

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

Unit I: 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.

Unit II: Design and Analysis of Hydraulic Circuits [7]

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 [7]

Microprocessor - Basic architecture and its Busses, programming model, internal data operation and registers, controls and status signals, instruction sets, addressing modes.

Microcontroller: Microcontroller based manufacturing systems.

Unit V: Control System [7]

Data conversion (ADC/DAC), Programmable logic controller, Interfacing circuits, Actuating signals, relays, contactors, Types of control systems- P, PI, PID , Optimal control system.

Case studies on electrohydraulic and electro-pneumatic circuits.

Unit VI: Introduction to 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).

Text Books:

1. Kuo B.C., Golnaraghi F. (2014) Automatic control systems, Wiley, ISBN: 978-8126552337
2. Peter Rohner (1995) Industrial hydraulic control, Wiley Edition, 1995, ISBN: 0471334987
3. Mikell P Groover, (2015) Automation, Production System and Computer Integrated Manufacturing, Pearson, ISBN 978-0-13-349961-2
4. Mujumdar S.R.(2002) Pneumatic Systems, Tata McGraw Hill, ISBN: 9780074602317
5. Gopal M., Control (2012), McGraw Hill Education (India) Private Limited., ISBN 9780071333269

Reference Books:

1. Doebelin E.O, Measurement System (2008), Application and Design, Tata McGraw Hill Publications Ltd., New Delhi, ISBN 0-07–17338-9.
2. Bolton W. (2015) Mechatronics Electronic Control Systems in Mechanical and Electrical Engineering Pearson Education (Singapore) Pvt Ltd., ISBN 9781292076683
3. Rangan C.S., Sharma G.R., Mani V.S. (2008), Instrumentation - Devices and Systems, McGraw Hill , ISBN 9780074633502.
4. Johnson C.D. (2014), Process Control Instrumentation Technology, Pearson, ISBN 978-1-292-02601-5.

411082(A): Operations Research

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

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

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

1. Formulate and solve linear programming problem.
2. Formulate and solve transportation and assignment problem
3. Evaluate integer, dynamic, goal and geometric programming
4. Plan optimum replacement strategies in various replacement situations.
5. Apply knowledge of decision making Theory and game Theory to real-world decision situations
6. Demonstrate different queuing situations

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

Definition of Operations Research: Objectives, Simplex methods for maximization and minimization problems: Formulation, Degeneracy in L.P., Duality in L. 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 salesman 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 constant rates 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, Poisson single and 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. Sharma S.D.,(2012) Operations Research, Kedarnath Ramnath and company publications, ISBN: 978-9380803388
2. Gupta P.K., Hira D.S.,(1976) Operations Research‖, S Chand and Co. Ltd., New Delhi ISBN: 978-8121902816
3. Taha H.A.,(2016) Operations Research - An introduction, Pearson Education Ltd. ISBN: 978-0134444017
4. P. Shankaralyer,(2008) Operations Research Sigma Series, Tata McGraw-Hill. ISBN:, 9781283922487
5. Rao, S. S.(2009) Engineering Optimization: Theory and Practice‖, John Wiley & Sons. ISBN: 978-0470183526

Reference Books:

1. Hillier F.S., Lieberman G.J.,(2005) Introduction to Operations Research‖, Tata McGraw-Hill, ISBN: 978-0070600928
2. Wagner H.M.,(1975) Principles of Operations Research, Prentice-Hall India, ISBN: 978-0137095926,
4. Basu S.K., Pal D.K., and Bagchi H., Operations Research for Engineers‖, Oxford and IBH Publishing Co. Pvt.Ltd., ISBN 81-204-1251-6.
5. Panneerselvam R., (2004) Operations Research‖, Prentice Hall of India Ltd., New Delhi. ISBN: 978-8120329287

411083(A): Simulation, Modelling and Digital Twin

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

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Pre-requisites: Engineering Mathematics, Design of Machine Elements, Computer Aided design, CAD (Computer Aided Engineering for work), basic programming (e.g. Java, Python, Matlab)

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

1. Explain the techniques of modelling and simulation.
2. Simulate the models for the purpose of optimum control by using software.
3. Describe what digital twins are and their applications in industry
4. Identify the functions of a digital twin and its boundaries.
5. Develop a digital twin application.

Unit 1: Introduction to Simulation (7)

System and System Environment, Components of System, Discrete and Continuous System, System Simulation, Model of a System, Types of Model, Use of Differential and Partial differential, equations in Modelling, Advantages, Disadvantages and Limitations of Simulation, Application, Areas, Phases in Simulation Study

Unit 2: Simulation of Continuous and Discrete System (7)

Continuous System Models, Analog Computer, Analog Methods, Hybrid Simulation, Digital-Analog Simulators, Feedback Systems, Discrete Event Simulation, representation of time, Simulation Clock and Time Management, Models of Arrival Processes - Poisson Processes, Non-stationary Poisson Processes, Batch Arrivals; Gathering statistics, Probability and Monte Carlo Simulation, Markov Chain

Unit 3: Analysis, Verification and Validation of simulation systems (7)

Design of Simulation Models, Verification of Simulation Models, Calibration and Validation of the models, Three-Step Approach for Validation of Simulation Models, Accreditation of Models Confidence Intervals and Hypothesis Testing, Estimation Methods, Simulation run statistics, Replication of runs, Elimination of initial bias

Unit 4: Digital twin (7)

Definition, types of Industry and its key requirements, Importance, Application of Digital Twin in process, product, service industries, History of Digital Twin, DTT role in industry innovation, Technologies/tools enabling Digital Twin

Unit 5: Digital Twin in a Process Industry (7)

Basics of Process Industry, Trends in the process industry, control system requirements in a process industry, Digital Twin of a plant, Digital Thread in process Industry, Data collection and analysis for process improvements, process safety, Automation simulation, Digital Enterprise

Unit 6: Applications of Digital Twin **(7)**

Improvement in product quality, production process, process Safety, identify bottlenecks and improve efficiency, achieve flexibility in production, continuous prediction and tuning of production process through Simulation, reducing the time to market.

Text books:

1. Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol -Discrete Event System Simulation, III Edition, Pearson Education, Asia, (2001) ISBN - 81- 7808 - 505 - 4.
2. Narsingh Deo -Systems Simulation with Digital Computer; PHI Publication (EEE),(2011) ISBN - 0- 87692-028-8
3. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019, ISBN: 9780128176306

Reference:

1. Averill M Law, W David Kelton -Simulation Modeling & Analysis, McGraw Hill International Editions - Industrial Engineering series, (1991) ISBN - 0-07-100803-9.
2. Shyam Varan Nath and Pieter van Schalkwyk, Building Industrial Digital Twin, Packt Publishing Limited, (2021) ISBN-13 : 1839219078-978
3. Manisha Vohra, Digital Twin Technology, Wiley, 2022, ISBN: 9781119842200

411083 (A) Total Quality Management (Elective-III)

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

Prerequisites: Industrial Engineering and Management, Production and Operations Management

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

1. Demonstrate quality, quality dimensions, TQM principle and barriers
2. Implement principles of TQM
3. Apply seven quality tools to different industrial scenario
4. Evaluate reliability, maintainability, availability of a machines
5. Perform quality audits and report writing

Unit I: Introduction (6)

Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs steps in reporting on quality cost - Basic, concepts of Total Quality Management, Historical Review, Principles of TQM, and Quality in Business and commerce, Leadership Principles, Role of Senior Management, Economic Issues - Quality and Price - Quality and Market Share - Quality and Cost, Quality Council, Quality Statements, strategic quality planning, service quality and product quality, determinants of service quality, Barriers to TQM Implementation.

Unit II: Principles of Total Quality Management (6)

Elements of TQM, Benefits of Total TQM, customer satisfaction, customers perception of quality, Customer Complaints , Service Quality Customer Retention Employee Involvement Teamwork, Training, Recognition and reward, performance Appraisal, Continual process Improvement, Supplier partnership, Performance measures Deming's 14 Point programme - PDCA Cycle, The Juran Philosophy - The Juran Quality Trilogy. The Crosby and 14 Point programme. The Taguchi Loss Function, 5S, Kaizen,

Unit III: TQM Tools (6)

Ishikawa 's Seven Quality Tools, Ishikawa Fish bone diagram ,Quality Circles, Poka Yoke (Mistake Proofing), Zero defect, JIT, Kanban, Benchmarking, Benchmarking process, code of conduct for Benchmarking, Types of Benchmarking, Steps in Benchmarking, Advantages and limitations in Benchmarking Quality, Function Deployment (QFD), House of Quality, QFD Process, Benefits,

Total Productive Maintenance (TPM) Concept, FMEA, Stages of FMEA

Unit IV: Reliability (6)

Concept and Components , Types of failure , Reliability of system , Success and Failure models in series and parallel - Methods of achieving higher reliability - Concept of maintainability and availability ,Weibull Distribution (Bath Tub curve), Comparison with reliability ,MTBF, MTTF and FMEA

Unit V: Managing and organization for Quality (6)

Need for organizing for quality, evaluation of organization for quality, requirements for quality coordination of quality activities, organizing for creating change, organizing for quality implementation, Roles in organizational changes to TQM, Various teams for TQM , Control Charts for variables and attributes, Process capability, Concept of six sigma, Auditing Techniques - Planning for an audit -Developing a Check-list -Conducting an Audit - Writing an Audit Report - Auditor Ethics- Value -addition process during Internal Audit - Mock Audits.

Unit VI: Quality Management Standards: (6)

ISO-Introduction, Major elements of ISO 9001:2000, ISO 9001:2000 QMS Requirements, Implementation of ISO 9001, ISO documentation, quality system 9000,Environmental management systems, SO 14000 series standards, requirements of ISO14001,implementation and operation of EMS, Checking and corrective action, benefits of EMS, ISO 27001:2005 Information Security Management System, ISO / TS16949:2002 for Automobile Industry, CMMI Fundamentals and Concepts

Text Books

1. Dale H Bester, (2013) "Quality Control", Pearson Education, ISBN-13:9780135000953
2. Sundarrajan, (2011) "Total Quality Management", Pearson Education, ISBN-13: 9780130306517
3. Smith, (1998) "Quality Problem Solving", Quality Press, Wisconsin Avenue, USA, ISBN 9780873893947
4. James R.Evans and William M.Lidsay, (2002) "The Management and Control of Quality", 5th Ed., South-Western (Thomson Learning), ISBN-13:0324382358-978

Reference Books

1. Feigenbaum.A.V., (1991) "Total Quality Management", McGraw-Hill,. ISBN-13: 978-0070220034
2. Oakland.J.S., (1989) "Total Quality Management", Butterworth Hcinemann Ltd., Oxford.. ISBN-13 : 0128110355-978
3. Narayana V. and Sreenivasan, N.S., (1996) "Quality Management - Concepts and Tasks", New Age International. ISBN-13 : 8122408324-978
4. Zeiri, (1991) "Total Quality Management for Engineers", Wood Head Publishers, , ISBN-13 : 1855730243-978

411083(A): Artificial Intelligence in Manufacturing

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

Pre-requisites: Engineering Mathematics-II, Engineering Mathematics-III

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

6. Demonstrate basic concepts of Artificial Intelligence and Machine Learning
7. Classify appropriate of Artificial Intelligence method according to different manufacturing functions
8. Develop Artificial Intelligence model of given manufacturing system
9. Apply Artificial Intelligence and soft computing methods to manufacturing problems
10. Evaluate the performance of Artificial Intelligence methods

Unit I: Introduction to Artificial Intelligence and Machine Learning [7]

Definitions - Foundation and History of AI, Evolution of AI - Applications of AI area, Classification of AI systems with respect to environment. Industry 4.0, Application of AI in Manufacturing

Introduction to Machine Learning, Examples of Machine Learning Applications, Supervised, Unsupervised, and Semi-Supervised Learning, Reinforcement Learning, Linear Regression, Machine Learning and Big Data, Deep Learning, Artificial Intelligence vs Machine learning.

Unit II: Fuzzy Logic [7]

Basic Concepts of Fuzzy Logic, Fuzzy Set Theory, Fuzzy set versus Crisp set, Membership function, Operations on Fuzzy set, Fuzzy Relation, Fuzzification and Defuzzification, Minmax Composition, Fuzzy Logic, Fuzzy Rule based systems, Predicate logic, Fuzzy Decision Making, Fuzzy Control Systems, Fuzzy Classification, Fuzzy controllers, Fuzzy expert Systems, Application of Fuzzy systems (Real life)

Unit III: Genetic Algorithm [7]

Evolution of Genetic Algorithms (GA),Basic Concepts and working principle, Flow chart of GA, Genetic Representation, Basic GA framework and different GA architectures, GA operators: Crossover, Selection, Mutation, Fitness function, Convergence Working, Traditional Algorithm Vs Genetic Algorithm, Applications of Genetic Algorithm

Unit IV: Neural Networks [7]

Introduction, Learning rules and activation functions, Single layer and multilayer Perceptron's, Feed forward and Back propagation networks, Architecture of Back propagation (BP) Networks, Back propagation Learning mechanism, Boltzmann Machine, Types of Artificial Neural Network(ANN), Introduction to Associative Memory, Adaptive Resonance, Self Organizing Map, Recent applications (real life)

Unit IV: AI based methods for Process Control and Monitoring [7]

AI based Monitoring and control of discrete manufacturing process, Online process monitoring in additive manufacturing, Industrial Machine Vision.

Unit VI: AI Applications and Case Studies [7]

Applications of AI in Manufacturing: robot, Intelligent Vehicles, factory, Autonomous Aircrafts, design and manufacturing, warehouse management, predictive maintenance, inventory control, visual inspections and quality control, etc. optimization and control.

Case studies of typical applications in tool selection, process selection, part classification, inventory control, process planning, etc.

Text Books:

1. Pratihar D. K. (2018) Soft Computing, Narosa Publishing, ISBN: 978-81-8487-495-2
2. Rich E., Knight K., Nair S. B. (2014) Artificial Intelligence, TMH, ISBN-978-0-07 008770-5 (2014).
3. Groover Mikell P. (2015) Automation, Production System and Computer Integrated Manufacturing, Pearson, ISBN 978-0-13-349961-2
4. Tom Mitchell (1997) Machine Learning, McGraw- Hill, ISBN: 0070428077

Reference Books:

1. Stuart Russell and Peter Norvig (2003) Artificial Intelligence: A Modern Approach, Prentice Hall, ISBN: 978-0-13-604259-4
2. Goldberg David E. (2002) Genetic Algorithms In Search, Optimization And Machine Learning, Pearson Education, ISBN: 9788177568293
3. Simon Haykin (2011) Neural Networks and Learning Machines, PHI Learning, ISBN: 978-0131471399

411083(A): Elective III: World Class Manufacturing

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

Prerequisites: Production Management, Industrial Engineering and Quality Assurance.

Course Outcomes:

After successful completion of course student will able to,

1. Define challenges in world class manufacturing
2. Demonstrate various world class manufacturing strategies.
3. Describe total quality and employee involvement in manufacturing
4. Discuss different world class information system for change management.
5. Identify various methods and processes for WCM using brain storming.

Unit I: Historical Perspective **[7]**

World class excellent organizations- Models of world class manufacturing: Hall's framework of value -added engineering, Schonberger's framework of world class manufacturing, Various models of world class manufacturing, JIPM TPM Award, EFQM Award, RBNQA Award

Unit II: Benchmark, Bottlenecks and Best Practices **[7]**

Concepts of benchmarking, Bottleneck and best practices, Best performers- Gaining competitive edge through world class manufacturing - Value added manufacturing - Value Stream mapping - Eliminating waste -Toyota Production System-Example.

UNIT III: System for World Class Manufacturing **[7]**

Improving Product & Process Design - Lean Production, procurement & stores practices, total Productive maintenance, Visual Control

Unit IV: Tools for World Class Manufacturing **[7]**

SQC, FMS, Poka Yoke, 5-S, 3 M, JIT,Product Mix, MURA Analysis, MUDA Analysis, Spaghetti Chart, MURI, SOP, Poka-Yoke

Unit V: Human Resource Management in WCM **[7]**

Adding value to the organization- Organizational learning - techniques of removing Root cause of problems-People as problem solvers-New organizational structures. Associates-Facilitators- Teams man ship -Motivation and reward in the age of continuous improvement.

Unit VI: Indian Scenario **[7]**

Case studies on leading Indian companies towards world class manufacturing -Task Ahead. Green Manufacturing, Clean manufacturing, Agile manufacturing

Text Books

1. K. Shridhara Bhat, World Class Manufacturing, Himalaya Publication House, Mumbai.(2007 edition)
2. B. S. Sahay, K B C Saxena, Ashish kumar, World Class Manufacturing Strategic Perspective, Mac Milan Publication, New Delhi

Reference Books:

1. Panner selvam, Production and Operation Management, Prentice Hall of India.
2. Martand T.Telsang Industrial Engineering and Production Management,S.Chand& Co.
3. Jeffrey K. Liker, The Toyota Way, Tata McGrow Hill.

411084 (A): Plant Maintenance and Industrial Safety

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

Pre-requisites: Manufacturing Processes, Heat and Fluid Engineering.

Course outcomes

1. Describe the various categories of maintenance.
2. Assemble, dismantle and align mechanisms in sequential order.
3. Carry out plant maintenance using tribology, corrosion and preventive maintenance.
4. Student gets the exposure of Maintenance Policies and Preventive Maintenance.
5. Explain the Industrial safety measures and acts.

Unit I: Introduction, Principles and Practices of Maintenance Planning (07)

Definition and aim of maintenance engineering. Primary and secondary functions and responsibility of maintenance department. Principles of maintenance planning - Objectives and principles of planned maintenance activity - Importance and benefits of sound Maintenance systems - Reliability and machine availability, Equipment Life cycle, Measures for Maintenance Performance: Equipment's breakdowns, Mean Time Between Failures, Mean Time To Repair, Factors of availability, Maintenance organization, Maintenance economics.

Unit II: Periodic and Preventive Maintenance and Maintenance Policies (07)

Periodic inspection-concept and need. Maintenance categories - Comparative merits of each category - Preventive maintenance, Maintenance schedules: Repair cycle, Principles and methods of lubrication, Fault Tree Analysis, Total Productive Maintenance: Methodology and Implementation.

Unit III: Condition Monitoring (07)

Condition Monitoring: Cost comparison with and without Condition Monitoring, On-load and off-load testing. Methods and instruments for Condition Monitoring, Temperature sensitive tapes, Pistol thermometers, wear-debris analysis, noise vibration and harshness analysis of machines.

Unit IV: Introduction to the Development of Industrial Safety and Management (07)

History and development of Industrial safety: Implementation of factories act, Formation of various councils, Safety and productivity, Safety organizations. Safety committees, safety committee structure, Roll of management and roll of Govt. in industrial safety, Safety analysis.

Unit V: Accident Preventions, Protective Equipment and the Acts (07)

Personal protective equipment, Survey the plant for locations and hazards, Part of body to be protected, Education and training in safety, Prevention causes and cost of accident, Housekeeping, First aid, Fire fighting equipment, Accident reporting, Investigations, Industrial psychology in accident prevention, Safety trials.

Unit VI: Safety Acts (07)

Features of Factory Act, Introduction of Explosive Act, Boiler Act, ESI Act, Workman's compensation Act, Industrial hygiene, Occupational safety, Diseases prevention, Ergonomics, Occupational diseases, stress, fatigue, health, safety and the physical

environment, Engineering methods of controlling chemical hazards, safety and the physical environment, Control of industrial noise and protection against it, Code and regulations for worker safety and health.

Text Books:

1. Srivastava, S.K., "Industrial Maintenance Management", S. Chand and Co. ISBN-10: 8121916631, ISBN-13: 978-8121916639
2. Bhattacharya, S.N., "Installation, Servicing and Maintenance", S. Chand and Co., ISBN: 9788121908313
3. Willie Hammer, "Occupational Safety Management and Engineering", Prentice Hall ISBN: 9781551642956.

Reference Books:

1. Eugene N. White, "Maintenance Planning, Control and Documentation", Gower Press, ISBN: 978-0566021442
2. Garg H.P., "Industrial Maintenance", S. Chand and Co., ISBN: 978-8121901680
3. Keith Mobley, Lindley R. Higgins, Darrin J. Wikoff, "Maintenance Engineering Hand book", 5th Edition, McGraw Hill, ISBN:9780071641012, 0071641017
4. Davies, "Handbook of Condition Monitoring: Techniques and Methodology", Springer Netherlands, ISBN:9789401149242,
5. C. Ray Asfahl, David W. Rieske, "Industrial Safety and Health Management", 5th Edition, Prentice Hall ISBN:9780132368711
6. R.C.Mishra, "Reliability and Maintenance Engineering", New Age Publishing house, ISBN:9788122417418

411084 (A) - Elective IV: Surface Engineering

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

Pre-requisites: Material Science and Metallurgy, Manufacturing Processes, Machining science and technology.

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

1. Demonstrate basic concepts of various surface treatments
2. Decide the surface treatment required for specific material and application.
3. Use various surface cleaning processes.
4. Select appropriate coating required for specific material and its application.
5. Test the surface of material for required properties.

Unit I: Introduction of Surface Dependent Properties (7)

Introduction to various corrosion prevention methods. Classification and scope of surface modification techniques in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials. Surface dependent engineering properties, viz., wear, friction, corrosion, fatigue, reflectivity, emissivity, etc.; common surface initiated engineering failures; mechanism of surface degradation; importance and necessity of surface engineering

Unit II: Surface Cleaning Processes (7)

Classification and Selection of Cleaning processes. Acid and Alkaline Salt bath, Ultrasonic, Mechanical cleaning, Pickling and descaling, etc. Process details, applications & Environmental concern of each method, Electrochemistry and electro-deposition; electro less deposition. Process details. Scope and application of conventionally deposited materials like Copper Nickel etc.

Unit III: Coatings (7)

Various types like Cathodic & Anodic coatings, Hot dipping (Tinning, Galvanizing, Aluminizing), Metal cladding. Diffusion coatings like carburizing, nitriding, cyaniding, Sherardizing, Calorizing & Chromizing. Chemical conversion coatings like Phosphate; Chromate

Oxide, Anodized. Various Organic coatings like Paints, varnishes, Enamel & Lacquers Thermal spray coatings- Various types like Flame spray, Electric arc spray, Plasma spray, High velocity Oxy Fuel (HVOF). Scope, Process and application; advantages and limitations of the above mentioned processes.

Unit IV: Other Surface Engineering Processes (7)

Influence of manufacturing processes on various surface properties of an engineering component; scope of surface engineering in augmentation of surface properties. Other processes used in surface engineering - Physical vapour deposition, Chemical vapour deposition.- Process, applications. Mass production; surface engineering problems related to substrate characteristics. Plasma enhanced Surface engineering, Ion Implantation. Diamond and Diamond like Carbon thin films and coatings for engineering surfaces.

Unit V: Testing & Characterization of Coatings (7)

Control properties, response properties; surface geometry characterization Techniques (conventional and recent trends); coating thickness measurements - laboratory techniques and special techniques for accurate routine thickness measurements; adhesion measurement, conventional methods and recent developments; Quality assurance of coating process.

Unit VI: Recent Trends in Surface Engineering (7)

Measurement of mechanical properties of engineered surface in nano scale; Evaluation of tribological characteristics of engineered surface in macro, micro and nano scale, simulation of actual application environment in tribometer. High temperature coatings, Wear

resistant coatings Use of Laser in Surface Engineering, Environmental protection issues.

Text Books

1. D. Sriniwasa Rao, Shrikant V. Joshi, "Surface Engineering", Daya Publishing House, ISBN: 9788170356288, 9788170356288
2. M. Kamaraj, V. M. Radhakrishnan, "Basics of Surface Technology", New Age International (p) Ltd., ISBN: 9788122439601

Reference Books

1. Bharat Bhushan, "Introduction to Tribology" John Wiley & Sons, ISBN: 0471158933
2. B. N. J. Persson, "Sliding Friction: Physical Principles and Applications" Springer, ISBN: 978-3540671923
3. Gwidon Stachowiak, A W Batchelor, "Engineering Tribology", Butterworth-Heinemann, Hardcover ISBN: 9780750678360, eBook ISBN: 9780080531038
4. ASM Hand Book, Vol. 5, "Surface Engineering". ISBN: 9780871703842
5. Bhushan B. and Gupta B. K., "Handbook of Tribology: Material, Coatings and Surface Treatments", McGraw Hill Ltd.
6. Davis J., "Surface Engineering for Corrosion and Wear Resistance", Woodhead Publishing, 2001. ISBN 10: 0871707004ISBN 13: 9780871707000
7. Tadausz Burakowski, "Surface Engineering of Metals: Principles, Equipments and Technologies", Taylor and Francis.

411084(A)-Elective IV: Reverse Engineering

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

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Pre-requisites: Computer Aided Design, Electrical & Electronics Engineering, Design of Machine Elements.

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

1. Interpreting the terminologies related to re-engineering, forward engineering, and reverse engineering.
2. Disassemble products and specify the interactions between its subsystems and their functionality
3. Implement the Reverse Engineering methodologies.
4. Apply reverse engineering system to automotive, aerospace, medical device industries.

Unit I: Introduction to Reverse Engineering (7)

What is Reverse Engineering, Use of Reverse Engineering, Reverse Engineering-The Generic Process, Scanning: Contact Scanners, Noncontact Scanners, Point Processing, Application Geometric Model Development.

Unit II: Methodologies and Techniques for Reverse Engineering (7)

3-D Laser Scanners, Computer-aided Reverse Engineering, What Is Not Reverse Engineering, Computer-aided (Forward) Engineering, Computer-aided Reverse Engineering, Computer Vision and Reverse Engineering, Coordinate Measuring Machines, Active Illumination 3-D Stereo: Benefits and Drawbacks, Structured-light Range Imaging, Source Illumination Categories, sheet-of-light Range Imaging, Scanner Pipeline, Data Collection, Mesh Reconstruction, Surface Fitting.

Unit III: Reverse Engineering–Hardware and Software (7)

Introduction, Reverse Engineering Hardware, Contact Methods, Noncontact Methods, Destructive Method, Reverse Engineering Software, Reverse Engineering Software Classification, Reverse Engineering Phases, Fundamental Reverse Engineering Operations.

Unit IV: Selection of a Reverse Engineering System (7)

The Selection Process: Identify the Business Opportunity and Technical requirements, Vendor and System Information Gathering, Benchmarking, Point Capture Devices, contact Devices-Hard or Manual Probe, Touch-trigger Probe, Continuous Analogue Scanning Probe, Noncontact Devices, Triangulation, "Time-of-flight" or Ranging Systems, Structured-light and Stereoscopic Imaging Systems, Issues with Light-based Approaches, Tracking Systems, Internal Measurement Systems, X-ray Tomography, Destructive Systems, Positioning the Probe, Postprocessing the Captured Data, Handling Data Points, Curve and Surface Creation, Inspection Applications, Manufacturing approaches

Unit IV: Rapid prototyping for Reverse Engineering (7)

Modeling Cloud Data in Reverse Engineering, Data Processing for Rapid Prototyping, Integration of RE and RP for Layer-based Model Generation, The Adaptive Slicing Approach for Cloud Data Modeling, Planar Polygon Curve Construction for a Layer, Correlation Coefficient, Initial Point Determination, Constructing the First Line Segment (S1), Constructing the Remaining Line Segments (Si, Determination of Adaptive Layer Thickness)

Unit VI: Applications of Reverse Engineering **(7)**

Applications of Reverse Engineering in Automotive Industries, Aerospace Industries, Medical Device Industries, Legal Aspects of Reverse Engineering, Barriers to Adopt Reverse Engineering

Reference books:

1. K. Otto and K. Wood (2001) Product Design: Techniques in Reverse Engineering and New Product Development, Prentice Hall (ISBN 10: 0130212717 / ISBN 13: 9780130212719).
2. Raja and Fernandes (2008) Reverse Engineering: An Industrial Perspective, Springer-Verlag (ISBN: 978-1-84628-855-5).
3. Sokovic and Kopac (2006) RE as necessary phase by rapid product development, Journal of Materials Processing Technology, Elsevier (doi:10.1016/j.jmatprotec.2005.04.047).
4. Eldad Eilam (2005) Reversing: Secrets of Reverse Engineering, Wiley (ISBN : 0-7645-7481-7).
5. Robert W. Messler (2014) Reverse Engineering: Mechanisms, Structures, Systems & Materials, McGraw-Hill Education (ISBN: 9780071825160).

411084 (A)-Elective IV: Entrepreneurship and Innovations

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

Pre-requisites: Industrial Engineering and Management, Production Management

Course outcomes:

After Successful completion of this course students will able to:

1. Describe various aspects of innovation and methods of fostering Innovation
2. Appreciate the importance of embarking on self-employment and has developed the confidence and personal skills for the same.
3. Start a small business enterprise by liaising with different stake holders
4. Effectively manage small business enterprise.

Unit I: Introduction to Innovation **(7)**

Creativity, Invention and innovation, Types of Innovation, Relevance of Technology for Innovation, The Indian innovations and opportunities, Promoting and managing innovation, Innovators and Imitators, Patents, Trademarks, Intellectual Property, Exploring, Executing, Leveraging and renewing innovation, Enhancing Innovation Potential & Formulating strategies for Innovation

Unit II: Strategy for Commercializing Innovation **(7)**

Innovation Process, Risks and barriers for introducing products and services, selecting a Strategy, setting up the Investment and establishing organisation, Evaluating the Costs and impact of the Project

UNIT III: Entrepreneurship **(7)**

Definition. Growth of industries in developing countries; role of industries in the national economy; characteristics; demand based and resources based ancillaries and sub-control types. Government policies, stages in starting an industry, types (family business/start-ups etc.), Sources of finance.

UNIT IV: Project identification and accountancy **(7)**

Assessment of viability, formulation, evaluation, financing, field-study and collection of information, preparation of project report, demand analysis, material balance and output methods,

Accountancy: Preparation of balance sheets and assessment of economic viability, decision making, expected costs, planning and production control, preparation of financial reports, accounts and stores studies.

UNIT V: Project Planning and control **(7)**

The financial functions cost of capital approach in project planning and control. Economic evaluation, risk analysis, capital expenditures, policies and practices in public enterprises. Profit planning and programming, planning cash flow, capital expenditure and operations. Control of financial flows, control and communication.

UNIT VI: Laws **(7)**

Laws concerning entrepreneur viz, partnership laws, business ownership, sales and income taxes and workman compensation act. Role of various national and state agencies which render assistance to small scale industries.

Text Books:

1. Robin Lowe and Sue Marriott, Enterprise: Entrepreneurship and Innovation Concepts, Contexts and Commercialization, ISBN: 978-0-7506-6920-7
2. Khanka. S.S., ¯Entrepreneurial Developmen, S.Chand & Co. Ltd.,Ram Nagar, New Delhi, 2013. ISBN: 978-81-219-1801-5
3. Donald F Kuratko, ¯ Entreprenuership - Theory, Process and Practice‖, 9th Edition, Cengage Learning 2014. ISBN:9781305576247, 1305576241

Reference Books

1. Rabindra N. Kanungo “Entrepreneurship and innovation”, Sage Publications, New Delhi, 1998. ISBN:9780761992844, 0761992847
2. Peter F. Drucker, Innovation and Entrepreneurship, ISBN:9780750685085, 0750685085
3. John Forbat, “Entrepreneurship: The Seeds of Success”, Harriman House, 2007, ISBN: 1905641257; 9781905641253.
4. Veerbhadrappa Havinal, “Management and Entrepreneurship”, 2009, New Age International, ISBN:9788122426021, 8122426026
5. Joseph, L. Massod, Essential of Management", Prentice Hall of India.

411081(B): Automation & Control Engineering Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Pr/Or: 01	Term-work: 25 Marks Practical: 25 Marks

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The term work shall consist of assignments based on the following topics. Evaluation of practical will be based on practical examination.

Practical Work: (Any six from 1 to 7, 8th and 9th are compulsory)

1. Experiment on measurement of hydraulic pump efficiency.
2. Experiment on design of speed control hydraulic circuits.
3. Experiment on design of regenerative circuits
4. Experiment on design of electro-hydraulic sequencing circuits
5. Experiment on pneumatic circuits by demonstrating logic gates.
6. Experiment on electro-pneumatic circuits
7. Experiment on programmable logic controllers: Ladder logic programming
8. Microprocessor programming for basic operations.
9. *Industrial visit report on automation in any Industry.

* Industrial visit is compulsory.

Note: Use any relevant simulation software (freeware- fluid-sim, fluid-demo etc.) to validate the results of experiment no. 1 to 7.

411082(B): Operations Research Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Pr/Or: 01	Term work: 50 Marks

Term Work:

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.

411083(B): Simulation, Modelling and Digital Twin Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 2 hours / week	Pr/Or: 1	Term work: 50 Marks

Term work shall consist of Programming/Assignment/Case studies on Simulation, Modelling and Digital Twin, based on each unit.

411083(B) Total Quality Management (Elective-III) Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 2 hours / week	Pr/Or: 1	Term work: 50 Marks

Term work shall consist of Assignment/Case studies on Total Quality Management, based on each unit.

411083 (B): Artificial Intelligence in Manufacturing Lab

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

Write computer programs in python/matlab to solve the real-world problems in manufacturing using the following artificial intelligence and machine learning methods:

1. Linear Regression,
2. Logistic Regression,
3. Multi-Class Classification,
4. Neural Networks,
5. Support Vector Machines,
6. K-Means Clustering
7. Genetic Algorithms
8. Fuzzy logic

411083(B): Elective III: World Class Manufacturing Lab

Teaching Scheme	Credit Scheme	Examination Scheme
02 hours/week	Pr/Or:02	Term work:50Marks

The term work shall be based on the following Practical Sessions:

1. Assignment on overview of Historical Perspective world class manufacturing.
2. Assignment on Benchmark, Bottlenecks and Best Practices used in world class manufacturing
3. Assignment on Lean Production and Procurement System for World Class Manufacturing
4. Assignment on SQC, FMS, Poka Yoke, 5-S, 3 M, and JIT Tools for World Class Manufacturing
5. Assignment on Human Resource Management in WCM
6. Case studies on leading Indian companies towards world class manufacturing

411084 (B): Plant Maintenance and Industrial Safety Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:02hours/week	Pr/Or:01	Term Work: 25Marks Oral:50Marks

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Term work will be based on following six assignments:

1. Introduction, principles and practices of Maintenance planning
2. Periodic and preventive maintenance and Maintenance policies
3. Condition Monitoring
4. Introduction to the development of industrial safety and management
5. Accident preventions, protective equipment and the Acts
6. Industrial safety acts

411084 (B) - Elective IV: SURFACE ENGINEERING

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 02 hours / week	Pr/Or: 01	OR: 25 Marks

Term work: Term work will consist of one exercise on each unit.

411084(B)-Elective IV: Reverse Engineering

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

Term Work:

Students should write assignment on (with the help of research papers, case study, etc.)

1. Assignment 1. Introduction to Reverse Engineering
2. Assignment 2. Methodologies and Techniques for Reverse Engineering
3. Assignment 3. Reverse Engineering-Hardware and Software
4. Assignment 4. Selection of a Reverse Engineering System
5. Assignment 5. Rapid prototyping for Reverse Engineering
6. Assignment 6. Applications of Reverse Engineering

411084 (B)-Elective IV: Entrepreneurship and Innovations

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

Term work will be based on six assignments from following:

1. Introduction to Innovation.
2. Strategy for commercializing Innovation.
3. Introduction to Entrepreneurship.
4. Project identification and Accountancy.
5. Project planning and control.
6. Laws concerning entrepreneur.

411085: MOOCs

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

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.

411086: Project Stage-I

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 02 hours / week	Pr/Or: 02(TW-1 & Oral-1)	Term-work: 50 Marks

Pre-requisite:

1. Students are required to undergo 3 to 4 weeks industrial training / implant training /in-house project based learning/project related skill development course/ industrial survey report before commencement of first semester of Final year
2. Submit detailed report of 10-15 pages of the same.
3. Project registration will be based on completion of above activities.

The student shall take up a suitable project, the scope of the project shall be such as to complete it within the time schedule, and the term work shall consist of:

1. Fabrication of models, machines, prototypes based on new ideas, robots and machine based on hi-tech systems

and automation, experimental set-up, fabrication of testing equipment, renovation of machines, etc. **Students shall submit the project phase –II plan.** Above work shall be taken up individually or in groups. *The group shall not be more than 4 students,* ***(If project work is more then group members may be increased by permission of guide)***

OR

Extensive analysis of some problems done with the help of a computer individually or in a group not exceeding two students.

2. A detailed report on the work done shall include project specification, design procedure, drawings, process sheets, assembly procedure and test results etc. Project may be of the following types:
    i. Manufacturing / Fabrication of a prototype machine' including selection, concept, design, material, manufacturing the components, assembly of components, testing and performance evaluation
    ii. Improvement of existing machine / equipment / process.
    iii. Design and fabrication of Jigs and Fixtures, dies, tools, special purpose Equipment, inspection gauges, measuring instruments for machine tool,
    iv. Computer aided design, analysis *of* components such as stress analysis.
    v. Problems related to Productivity improvements/Value Engineering/Material Handling Systems
    vi. Energy Audit of an organization, Industrial evaluation of machine devices.
    vii. Design of a test rig for performance evaluation of machine devices.
    viii. Product design and development.
    ix. Analysis, evaluation and experimental verification of any engineering problem
    x. Quality systems and management. Total Quality Management.
    xi. Quality improvements, In-process Inspection, Online gauging.
    xii. Low cost automation, Computer Aided Automation in Manufacturing.

xiii. Time and Motion study, Job evaluation and Merit rating
xiv. Ergonomics and safety aspects under industrial environment
xv. Management Information System.
xvi. Market Analysis in conjunction with Production Planning and Control.

OR

Computer based design / analysis or modeling / simulation of product(s), mechanism(s) or system (s) and its validation or comparison with available benchmarks / results. When a group of students is doing a project, names of all the students shall be included on every certified report copy. Two copies of project Report shall be submitted to the college. **The students shall present and submit their Project Phase-I report to the internal and external examiner from college/Industry.**

411087: Audit Course 7: Human Rights

Course outcomes

After completing the course the students will be able to:

1. Understand the importance and different approaches to Human rights
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. Analyse the functions of NHRC, Judiciary and PIL for 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, 2007
2 Darren J O Byrne,(ed), Human Rights: An Introduction, Pearson, New Delhi,2004
3 Chiranjeevi Nirmal, Human Rights in India, Oxford University Press, New Delhi,1997.
4 Pavithran K S,(ed), Human Rights in India: Discourse and Contentions, Gyan books, NewDelhi,2018
5 Ujwal Kumar Singh, (ed), Human Rights and peace: Ideas, Laws, Institutions and Movements, Sage, New Delhi,2009

411088(A): Computer Integrated Design and Manufacturing

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

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Pre-requisites:
Engineering drawing, Machine drawing, Dimensioning and tolerances, various geometrical features. Design of Machine Elements

Outcomes: After learning this subject, the student will be able to:
1. Apply geometric modeling principles to design a component
2. Solve problems in CAD using transformation method
3 Describe computer integrated manufacturing
4. Analyze the mechanical designs using finite element methods
5. Apply Group technology principles to design FMS

Unit I: Computer Graphics (7)
CAD cycle for product design, CAD workstations - data communications - input/output devices, display technology, CAD software. Transformation- Introduction, Formulation, Translation, Rotation, Scaling, Reflection, Homogenous Representation, Concatenated Transformation, Mapping of Geometric Models, Inverse Transformations.

Unit II: Geometric Modelling (7)
Requirements of geometric modeling, geometric models, Wireframe modeling, Surface modeling, geometric construction methods, constraint based modeling, Representation of curves and surfaces. Analytic curves- Lines, circles, circular arcs, ellipse, parabola, hyperbola etc. Synthetic curves - cubic splines, bezier curves, B-spline curve etc., Surface modeling -Representation of surfaces, analytical and synthetic surfaces. Solid modeling - Solid entities, methods of solid modeling

Unit III: Computer Integrated Manufacturing (CIM) and Rapid Prototyping (7)
Computer application in manufacturing automation, Computer aided inspection and quality control. Computer integrated production management system, inventory, material requirement planning, manufacturing resource planning, enterprise resource planning. Rapid Product Development and Manufacture, Extended Enterprises. Methods of rapid prototyping: steriolithography, Laminated Object Manufacturing (LOM), Fused Deposition Modeling (FDM), selective laser sintering, solid ground curing, 3D Printing system, Thermo jet Process, Ballistic Particle Manufacturing. Application of rapid tooling methods to press tool manufacture

Unit IV: Computer Aided Manufacturing (CAM) (7)
Concepts and features of NC, CNC & DNC - feed back devices ,Interpolators., Point-to-point and contouring systems - Interchangeable tooling system - preset & qualified tools - ISO specification - Machining center - Turning center , **CNC Programming:-** Machine Tool Co-ordinate System, Machine zero, Job zero, Cutter Programming, Tool Offsets, Manual part programming - steps involved - G-codes and M-codes, sample program in lathe & milling. CAM package – canned cycles - Programming.

Unit V: Computer Applications in Engineering Analysis (7)

Introduction, steps in FEA, Boundary conditions Co-ordinates and shape functions, Potential Energy Approach, Galerkin Approach, Assembly of Global Stiffness Matrix and Load Vector, Finite Element equations. Truss problems: Plane trusses, Three-dimensional trusses, Two dimensional problems: Finite element modeling, constant strain triangle, One Dimensional Problem and Two dimensional Problems and Boundary conditions.

Unit VI: Flexible Manufacturing System (7)

Part families - visual - parts classification and coding - case studies in coding - Production flow analysis - benefits of G.T. - Application of G.T. Cellular Manufacturing -Machine cell design - Key machine concept - quantitative analysis in cellular manufacturing - Rank order clustering technique - Arranging machines in G.T. Cell

FMS - Types of FMS - FMS components - Workstations, Material Handling and storage system - FMS Layout type, computer control system, Human resource - FMS application and benefits - FMS planning and implementation issues. Quantitative analysis of FMS – CANQ, deterministic models.

Text Books:

1. Radhakrishnan.P, Subramanyan.S and Raju.V, CAD/CAM/CIM, New Age International Publishers, 2000,ISBN:81-224-1248-3
2. Groover and Zimmers, CAD / CAM: Computer Aided Design and Manufacturing‖, Prentice Hall of India, New Delhi (1994), ISBN: 81-203-0402-0.
3. Zeid Ibrahim, CAD - CAM Theory and Practice‖, Tata McGraw Hill Publishing Co. Ltd New Delhi.(2000) ISBN:0-07-463991-4.
4. Kundra T.K., Rao P.N., Tiwari N.K., Numerical control and Computer aided manufacturing‖, Tata McGraw Hill 1992New Delhi, ISBN: 9780074517406.
5. Rao P.N, CAD - CAM Principles and Practice‖, Tata McGraw Hill Publishing Co. Ltd New Delhi.(2000) ISBN:0-07-044530-3.

Reference Books:

1. James A.Retrg and Henry W. Kraebher, Computer Integrated Manufacturing‖, Pearson Education, Asia, 2001
2. Viswamathan.N and Narahari.Y, Performance Modelling of Automated Manufacturing System‖, Prentice Hall of India Private Limited, ISBN:978-81-203-0870-1,Reprint2009
3. Chandrupatla T.R., Belegundu A.D., Introduction to Finite Elements in Engineering,Prentice Hall of India 2003.ISBN:13:9780130615916.

411089 (A): Industrial Robotics

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

Pre-requisites:

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

Course Outcomes:

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

1. Demonstrate the motions of robotic arm and body which generates robot configuration.
2. Apply the techniques like Homogeneous transformation to understand direct and inverse kinematics.
3. Design mechanical grippers depending upon their types and mechanism.
4. Classify different types of sensors
5. Able to convert black and white image from the given gray scale pattern.
6. Use different programming languages used to operate robot.
7. Suggest application of robots in different areas where they will work in future.

Unit 1: Fundamentals of robotics [7]

Automation and robotics, robot anatomy, historical development of industrial Robots and manipulators, basic structure of robots, resolution, accuracy and repeatability. Classification, Configuration of robots, arm and body motions, wrist motions. Robot Drives, Basic Control systems. End effectors - Grippers: Mechanical grippers, pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, RCC grippers - Two fingered and three fingered grippers - Internal grippers and external grippers - Selection and design considerations.

Unit II: 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).

Unit III: Robot Arm Dynamics [7]

Robot dynamics - Rigid body dynamics, Newton-Euler formation, Lagrange-Euler, formation, generalized D'Alembert equations of motion.

Unit IV: Sensors and Machine vision systems in Robotics [7]

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

Vision system: Median filtering, thresholding, discretization, smoothening of binary image. Edge detection algorithm, region growing algorithm.

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 Defining using 'via' point, blending Technique

Unit VI: Advanced Applications of Robots **[7]**

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

Text Books:

1. S. R. Deb, Sankha Deb, (2010), "Robotics Technology and Flexible Automation", Tata McGraw Hill Publications, New Delhi. ISBN: 978-007-007-7911
2. Yoram Koren, (1985) "Robotics for Engineers", McGraw Hill Book Co. ISBN: 978-007-035-3992.
3. Nicholas Odrey, Mitchell Weiss, Mikell Groover, Roger Nagel, Ashish Dutta, (2017), "Industrial Robotics -Technology ,Programming and Applications (SIE)", 2nd Edition, McGraw Hill Book Co., ISBN: 978-125-900-6210
4. King-Sun Fu, C.S.George Lee, Ralph Gonzalez, (1987), "Robotics: Control, Sensing, Vision and Intelligence", McGraw Hill Book Co., ISBN: 978-007-100-4213.

Reference Books

1. Hartenberg and Denavit, (1964),"Kinematics and Synthesis of Linkages", McGraw Hill Book Co. ISBN: 978-007-026-9101.
2. Hall A.S., (1966), "Kinematics and Linkage Design", Prentice Hall. ISBN: 978-088-133-2728.
3. Hirchhorn J., (2017), "Kinematics and Dynamics of Machinery", McGraw Hill Book Co., ISBN: 978-935-134-0201
4. Todd D.J., (1986), "Fundamentals of Robot Technology: An Introduction to Industrial Robots, Teleoperators and Robot Vehicles", Wiley Publications, ISBN: 978-047-020-3019.
5. Paul R., (1981), "Robot Manipulators Mathematics Programming & Control: Mathematics, Programming and Control (Artificial Intelligence)", MIT Press. ISBN: 978-026-216-0827.
6. Janakiraman P.A., (1995), "Robotics and Image Processing", Tata McGraw Hill, ISBN:978-007-462-1677.

Web References

1. https://nptel.ac.in/courses/112105249
2. https://nptel.ac.in/courses/112104298
3. https://nptel.ac.in/courses/112106304
4. https://nptel.ac.in/courses/112108298
5. https://robotacademy.net.au/masterclass/introduction-to-robotics/
6. https://see.stanford.edu/course/cs223a

411090(A): Elective V: E-Mobility In Automobile

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

Pre-requisites: Electrical & Electronics Engineering, Design of machine elements, Automobile engineering

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

1. To provide an understanding of architecture of Electric Vehicles (EVs).
2. To understand various types of electrical vehicle.
3. To understand types of EV motors and drive trains
4. To understand a storage of energy using different sources
5. To apply various techniques to communicate between system of EV
6. To understand how to Control Of Hybrid and Fuel Cell Vehicles and government rules

UNIT I: Introduction **(7)**

Overview of EVs and challenges - components of EVs - architecture of EVs - EV market and promotion-infrastructure needs - EV makers - Comparison in reference of: Energy source, Pollution, Energy diversification, Efficiency, Capital & operating cost, Performance.

UNIT II: Classifications **(7)**

Classification of EVs in reference of: Propulsion devices, Energy sources, Energy carriers, Pure Electric Vehicles (PEV) - Hybrid Electric Vehicles (HEV) and Plug-in Hybrid Electric Vehicles (PHEV)

UNITIII: EV Drives **(7)**

EV motors introductions - requirements - challenges - comparisons of EV motors and industrial motors - Motors (DC, Induction, BLDC, PMSM) - Types, Principle, Construction, Control - Electric Drive Train and its types.

Requirement of EV motor compared to industrial motors - classification of EV motors.

UNIT IV: Energy Storage **(7)**

EV energy source technologies: Energy sources used in EVs & HEVs - Medium of power transfer (conductive and wireless) - wireless power transfer - Battery Management System (BMS). CHARGING STATION -Solar Powered Electric Vehicle Charging Station - Calculation and Selection - Components of Charging Station - Earth protection system for charging stations - Requirement to prevent fire for EVs Charging Stations

UNIT V: EV Communication **(7)**

V2V, V2G and its applications in power system - power saving & coordinated charging - layout of power converters for V2G operation - EV configurations: converted & purpose built EVs - components of EV system

UNIT VI: Control of Hybrid and Fuel Cell Vehicles **(7)**

Fuel Cell Vehicles -Power Electronics Requirements - Propulsion Motor Control Strategies - APU Control System in Series

Hybrid Vehicles - Fuel Cell for APU Applications.

Government Rules - Regulations overview for electrical vehicle - Type approval Scheme.

Reference Books

1. Wei Liu, Hybrid Electric Vehicle System Modeling and Control, Wiley, ISBN 978-1119279327
2. M. Abdul Masrur, Hybrid Electric Vehicles - Wiley, ISBN 978-1118970560
3. Noshirwan K. Medora, Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market, ISBN 978-0444535658
4. M. Ehsani, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, ISBN 10-1498761771
5. 5.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, ISBN 978-0367693930

411090: Smart Manufacturing

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

Pre-requisites: Manufacturing Processes-I, Electrical and Electronics Engineering, Production and Operations Management,

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

1. Demonstrate basic concepts of smart manufacturing and Industry 4.0
2. Contextualize the operation data models for smart manufacturing
3. Build framework of data management system for smart manufacturing
4. Select appropriate computational framework for smart manufacturing.
5. Apply various optimization methods for multidisciplinary system design

Unit I: Implementing smart manufacturing [7]

Introduction to smart manufacturing, strategy and execution of smart manufacturing implementing smart manufacturing across an industrial organization, Industry 4.0

Unit II: Cyberinfrastructure for smart manufacturing [7]

Data centric view of smart manufacturing, building blocks of smart manufacturing, operational data models, contextualization, smart manufacturing profiles.

Unit III: Hardware, software and data management in smart manufacturing [7]

Hardware, software, modern data infrastructure approach for data collection and analysis, collecting data for intelligent analysis, condition based and predictive asset management,

Unit IV: Process modeling in smart manufacturing [7]

Model development, from data and model to value, model reduction, Industrial AI and predictive analysis

Unit V: Computational Framework for smart manufacturing [7]

Optimization methods for complex optimization systems, multidisciplinary system design optimization approaches, multi-criteria optimization,

Unit VI: Inferential modeling and soft sensors [7]

Characteristics of process data, inferential control and state estimation based approaches, data driven soft sensors, smart manufacturing as data enabled sustainable manufacturing

Text Books:

1. Soroush M, Baldea M, Edgar T F (2020) Smart Manufacturing: Concepts and Methods, Elsevier, ISBN: 978-0128200278
2. Uthayan Elangovan (2019) Smart Automation to Smart Manufacturing: Industrial Internet of Things, Momentum Press, ISBN: 9781949449266

Reference Books:

1. ZongWei Luo (2014) Smart Manufacturing Innovation and Transformation: Interconnection and Intelligence: Interconnection and Intelligence, IGI Global, ISBN: 9781466658370
2. Fortuna L, Graziani S, Rizzo A, Xibilia M G (2007), Soft Sensors for Monitoring and Control of Industrial Processes, Springer Science and Business Media, ISBN: 9781846284809

411090: Manufacturing System design

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

Pre-requisites: Production and operation management, Manufacturing science and technology, Process engineering and resource planning.

Course Outcomes:

After learning this subject, students will be able to:

1. Understand the basics of manufacturing systems design.
2. Understand the basics of Building Blocks of Manufacturing Systems.
3. Design a manufacturing system for a given product.
4. Apply the principles of cellular manufacturing systems and flexible manufacturing system toward new product design and development.
5. Understand the Lean Manufacturing and maintenance management techniques.

Unit I: Introduction of manufacturing systems [7]

Importance of manufacturing, Types of industry, Manufacturing System performance, Cost (fixed cost, variable cost) ,Productivity (system efficiency, system availability), Quality, Responsiveness, Safety, Paradigms of manufacturing-Batch, Mass production, Lean, Flexible, Mass customization, Reconfigurable Manufacturing

Unit II: Building Blocks of Manufacturing Systems [7]

Types of manufacturing processes: Machining, Assembly, Welding and joining, Forming, non-conventional processes.

Components of Manufacturing Systems: Processing Machines (workstations), Material Handling, Fixtures, Pallets, Buffers, controls, Measurement and inspection

Unit III: Procedure in manufacturing system design [7]

From machines to systems, Station level design issues, fixturing, Layout vs volume and variety, Configurations: Serial, Parallel, and Hybrid

Product to process planning, Task allocation and sequencing, Line balancing

Unit IV: Cellular Manufacturing & Flexible manufacturing Systems [7]

Part classification & coding, Production Flow analysis, Cellular Manufacturing Applications of Group Technology, Flexible Manufacturing Systems, Components, Applications and benefits, FMS planning, Quantitative analysis in FMS.

Unit V: Lean Manufacturing and Maintenance Management [7]

Evolution of Toyota (Lean) Production System, Principles of Lean production, Value stream Toyota production system, JIT, Pull, Flow, Zero inventories.

Maintenance strategies and planning, Maintenance economics: quantitative analysis, optimal number of machines, Replacement strategies and policies, economic service life, opportunity cost, replacement analysis using specific time period.

Unit VI: Manufacturing Support Systems and Reconfiguration of Manufacturing System [7]

Process Planning, Computer Aided Process Planning, Production planning and Control Systems, Aggregate Planning and Master Production schedule, Material Requirement Planning, Capacity Planning, Shop Floor Control, Overview of Automatic Identification and Data capture, Bar Code Technology and Radio Frequency Identification.

Reconfiguration of Manufacturing System, Needs for system reconfiguration, Principles of Reconfiguration.

Text books:

1. P. Radhakrishna and S. Subramanian (2008) -CAD/CAM/CIM, New Age International Publishers Wiley Eastern, ISBN: 9788122427180
2. Dr. K C Jain and Sanjay Jain (2012)-Principles Automation And Advanced Manufacturing Systems, Khanna Publishers, ISBN: 9788174091904

Reference books:

1. James. B. Dilworth (1992)-Operations Management – Design, Planning and Control for Manufacturing and Services, McGraw Hill Inc. Management Series, ISBN: 0071125841
2. Askin R G and Goldberg J B (2001)-Design and Analysis of Lean Production Systems, John Wiley and Sons Inc., ISBN:9780471115939
3. Mike Rother and John Shook, (2009)-Learning to See: Value-Stream Mapping to Create Value and Eliminate Muda, The Lean Enterprise Institute Cambridge, ISBN:9780966784305

411090: Ergonomics and Work Management

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

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Pre-requisites: Industrial Engineering

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

1. Analyze man machine interaction system for human comfort.
2. Evaluation of physiological functions for preventing accidents.
3. Application of anthropometry in practical life.
4. Demonstrate productivity improvement techniques.

UNIT I: Introduction [7]

Ergonomics: Introduction, history of development, man-machine system and its components. Introduction to structure of the body- features of the human body, stress and strain, metabolism.

UNIT II: Measure of physiological functions [7]

Workload and energy consumption, biomechanics, Types of movements of body members, strength and endurance, speed of movements. NIOSH lifting equation, Lifting Index, Maximum acceptable Weights and Forces, Distal upper extremities risk factors, Strain Index, RULA, REBA.

UNIT III: Applied anthropometry [7]

Types, use, principles in application, design of work surfaces and seat design. Visual displays for static information, visual displays of dynamic information, auditory, tactual and olfactory displays and controls. Assessment of occupational exposure to noise, heat stress and dust. Effect of vibration/ noise, temperature, illumination and dust on human health and performance.

UNIT IV: Introduction of work study [7]

Definition of productivity, factors affecting productivity, types of productivity and ways to improve productivity, objectives, work-study procedure, work simplification, human relations, workers, work study management, concept of work content, techniques to reduce work content.

UNIT V: Method study [7]

Definition, objectives, scope of method study, basic procedure, symbols and recording the facts, charting conventions, types of charts with individual case study, micro motion study, Critical examination and questioning technique, development and selection, implementation of method study.

UNIT VI: Work measurement techniques [7]

Definition, various techniques of work-measurement work-sampling, stopwatch time study & its procedure, Job selection, Equipment and forms used for time study, rating, methods of rating, allowances and their types, standard time, numerical problems, predetermined - time standards and standard data techniques.

Incentive: Meaning, objectives of an incentive plan, various types of incentive plans.

Text Books:

1. Introduction to Work Study - ILO International Labor Organization 4th edition 1992
2. Human Factor in Engineering and Design Mark. S. Sanders and Ernest. J Mc Cornick Mc Graw-Hill Book Co.,

Inc., New York,

Reference Books:

1. Barnes Ralph M., "Motion & Time study: Design and Measurement of Work", Wiley Text Books, 2001.
2. Marvin E, Mundel & David L, "Motion & Time Study: Improving Productivity", Pearson Education,2000Liou
3. Benjamin E Niebel and Freivalds Andris, "Methods Standards & Work Design", Mc Graw Hill, 1997.
4. International Labour organization, "Work-study", Oxford and IBH publishing company Pvt. Ltd., N.Delhi, 2001.
5. Sanders Mark S and McCormick Ernert J, "Human Factors in Engineering and Design", McGraw-Hill Inc.,

411091-Elective VI: Facility Planning

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

Pre-requisites: Basic Mathematics, Manufacturing processes

Course Outcomes:

1 Explain the impact that facilities planning has on the supply chain.

2. Define the strategic facilities 'planning requirements.

3. Determine flow systems, activity relationships, and space requirements work.

4. Apply concepts and techniques for material handling and layout modeling.

5. Apply the concepts and techniques for layout models

Unit I: Requirements of facility planning (7)

Introduction, product, process, and schedule design, Flow Systems, Activity Relationships, And Space Requirements, Personnel Requirements

Unit II: Developing alternatives: Concepts and Techniques (7)

Material Handling: Material Handling Principles, Unit load design, material handling equipment, handling cost, safety consideration.

Layout Planning Models And Design Algorithms: Basic Layout Types, Layout Procedures, Algorithmic Approaches, Department Shapes and Mail Aisles, Simulated Annealing and Genetic Algorithms, Multi-Floor Facility Layout, Commercial Facility Layout Packages, the Impact of Change, Developing Layout Alternatives

Unit III: Facility Design for Various Facilities Functions (7)

Warehouse Operations: Functions in the Warehouse, Receiving and Shipping Operations, Dock Locations, Storage Operations, Order Picking Operations

Manufacturing Systems: Fixed Automation Systems, Flexible Manufacturing Systems, Single-Stage Multi-machine Systems, Reduction in Work-in-Process, Just-in-Time Manufacturing, facilities Planning Trends

Unit IV: Facilities Systems (7)

Introduction, Structural System Performance, Enclosure Systems, Atmospheric Systems, Electrical and Lighting Systems, Life Safety Systems, Sanitation Systems, building Automation Systems, Facilities Maintenance Management Systems

Unit V: Developing Alternatives: Quantitative Approaches (7)

Introduction, Facility Location Models, Special Facility Layout Models, Machine Layout Models, Conventional Storage Models, Automated Storage and Retrieval Systems, Order Picking Systems, Fixed-Path Material Handling Models, Waiting Line Models, Simulation Models

Unit VI: Evaluating and implementing facility planning (7)

Selecting and Evaluating Facilities Plans, presenting, implementing and maintaining facility plans.

Text Books:

1. M. Telsang, 2018 -Industrial Engineering and Production Management, S. Chand Publication, ISBN 81 219 1773 5.
2. Mahajan M., 2005 -Industrial Engineering and Production Management, Dhanpat Rai and Sons Publishers, , ISBN-81-7700-047-0
3. Paneerselvam R., 2012 - Production and Operations Management, Prentice Hall India, 3rd Edition ISBN9788120345553
4. Mahajan M., 2005 - Industrial Engineering and Production Management‖ Dhanpat Rai and Sons Publishers, ISBN-81-7700-047-0

Reference Books:

1. Samuel Eilon,1991 - Production planning and control‖. Universal Publishing Corporation ISBN8185027099.
2. Joseph Monks, 1991 - Operation Management Theory and Problems‖, McGraw Hill Book Company, New York., ISBN007100579X.
3. F. L. Francis, J. A. White, L. F. McGinnis,1992 ¯Facilities Layout and Location‖, Prentice Hall of India Pvt. Ltd., ISBN 81-203-1460-3. 8120314603.
4. Richard Muther,1973 - Systematic Layout Planning, Van Nostrand Reinhold; 2nd edition ISBN978- 0933684065

411091: Elective VI: Additive Manufacturing

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

Pre-requisites: Material Science, Computer Aided Design

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

1. Identify the materials for used in additive manufacturing.
2. Identify the software for additive manufacturing and digitization techniques.
3. Identify industrial applications of liquid based additive manufacturing technology.
4. Identify industrial applications of solid based additive manufacturing technology.
5. Identify the industrial applications of powder based additive manufacturing.
6. Find applications of Bio-Additive Manufacturing- Computer Aided Tissue Engineering

Unit I: Introduction **[7]**

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

Unit II: CAD & Reverse Engineering **[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

Unit III: Liquid Based Additive Manufacturing Systems **[7]**

Liquid based system - Stereolithography Apparatus (SLA)- Principle, process, advantages and applications , Cubital‘s Solid Ground Curing (SGC), D-MEC‘s Solid Creation System (SCS), Meiko‘s Rapid Prototyping System for the Jewelry Industry, Rapid Freeze Prototyping, Microfabrication

Unit IV: Solid Based Additive Manufacturing Systems **[7]**

Solid based system -Fused Deposition Modeling - Principle, process, advantages and applications, Cubic Technologies‘ Laminated Object Manufacturing (LOM), Kira‘s Paper Lamination Technology (PLT), 3D Systems‘ Multi-Jet Modeling System (MJM), Beijing Yinhua‘s Slicing Solid Manufacturing (SSM), Melted Extrusion Modeling (MEM) and Multi-Functional RPM Systems (M-RPM)

Unit V: 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 MeltingUnit IV: Solid Based Additive Manufacturing Systems

Unit VI: 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. Chua C.K., Leong K.F., and Lim C.S., ―Rapid prototyping: Principles and applications‖, Third Edition, World Scientific Publishers, 2010.
2. Gebhardt A., ―Rapid prototyping‖, Hanser Gardener Publications, 2003.

Reference Books:

1. Liou L.W. and Liou F.W., ―Rapid Prototyping and Engineering applications: A tool box for prototype development‖, CRC Press, 2007.
2. Kamrani A.K. and Nasr E.A., ―Rapid Prototyping: Theory and practice‖, Springer, 2006.
3. Hilton P.D. and Jacobs P.F., ―Rapid Tooling: Technologies and Industrial Applications‖, CRC press, 2000.

411091: Elective VI: Reliability Engineering

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

Pre-requisites: Metrology and Quality Control

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

1. Identifyandanalyzethestaticanddynamicreliabilityofcomplexsystems.
2. Identify commonly used reliability techniques using graphical techniques and empirical distributions.
3. Utilize common physical models for reliability analysis.
4. Perform reliability analysis of complete data.
5. Acquire ability to root cause, correct, and document system failures.
6. Implement accelerated and highly accelerated life testing analyses.

Unit I: Fundamentals of Reliability Engineering [7]

Reliability definition, reliability concept, quality, failure, patterns of failure, causes of failure, Time to failure Distributions-experimental, Weibull ,gamma, normal, log normal, extreme value, model selection For components failure, failure analysis .failure density,failurerate,hazardrate,MTTF,MTBF,MTTR,MDT,unreliability,factor of safety and reliability, areas of reliability, life characteristic phases, bath-tub curve, Elements of Probability Theory: Set Theory, total probability theorem ,Bayes rule

Unit II: System reliability and modeling: [7]

Series, parallel, mixed configuration, k- out of n structure, complex systems- enumeration method, conditional probability method, matrix method, cut-set and tie-set method, Redundancy, element redundancy, unit redundancy, standby redundancy- types of standby redundancy, parallel components single redundancy, multiple redundancy. Markov analysis.

Unit III: Maintainability and Availability [7]

Objectives of maintenance, types of maintenance, Maintainability, factors affecting maintainability, system down time,Availability-Inherent,AchievedandOperationalavailability,reliabilityandmaintainabilitytrade-off.

Unit IV: System reliability Analysis [7]

Reliability allocation or apportionment, Reliability apportionment techniques - equal apportionment, AGREE, ARINC, feasibility of objectives apportionment, dynamic programming apportionment, Evaluation of overall system reliability, Reliability block diagrams and models, Reliability predictions from predicted unreliability, minimum effort method.

Unit V: Failure Mode, Effects and Criticality Analysis [7]

Failure mode effects analysis, severity/criticality analysis, FMECA examples, RPN, Ishikawa diagram for failure representation, fault tree construction ,basic symbols development of functional reliability block diagram, fault tree analysis, fault tree valuation techniques, minimal cutest method ,Delphi methods, Monte carloe valuation

Unit VI: Reliability testing and Failure Interaction sand Terro-technology [7]

Reliability growth models, grouped and ungrouped data, censored data, accelerated life testing, Markov analysis of two independent components, reliability with standby system, multi component systems, DTMC and CTMS models, Terro-technology, application of terrotechnology

Text Books:

1. L .S .Srinath, Concepts of Reliability Engg. Affiliated East-West Press (P) Ltd.,1985.ISBN-13:978-8176710480
2. E. Balagurusmy, Reliability Engineering, Tata McGraw-Hill Publishing Co. Ltd., 1984. ISBN9780074515341
3. Bhadury B. ,Basu S .K., Terotechnology Asian Books Private Limited, 2003. ISBN- 9788186299401
4. Reliability Engineering and maintenance‖, Asian Books Private Limited, ISBN81-86299-40-6

Reference Books:

1. A.K. Govil, 1983,Reliability Engineering, Tata McGraw-Hill Publishing Co.Ltd.,.ISBN-0074516558
2. B.S. Dhillion, C. Singh, 1980, Engineering Reliability‖, John Wiley & Sons,. ISBN-0471050148
3. M.L .Shooman, 1968 Probabilistic Reliability, McGraw-Hill Book Co.,. ISBN-0898748836
4. P.D.T .Conor, 1985 Practical Reliability Engg, John Wiley& Sons,. ISBN-9780470979822
5. K.C. Kapur, L.R. Lamberson, 1977 Reliability in Engineering Design, John Wiley & Sons,. ISBN-0471511919
6. A. Birolini, 1999 Reliability Engineering,Theoryand Practice‖, Third Edition, Springer, ISBN-3540663851
7. Rao S.S.,1992 Reliability Engineering, McGraw Hill ISBN-0070511926

411091: Elective VI: Data Analytics

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

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

Outcomes:

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

1. Effectively visualize and interpret the data
2. Apply predictive and prescriptive techniques for production engineering applications
3. Use data analysis for engineering applications through the powerful tools of data application

Unit 1: Introduction to data analytics [7]

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

Unit 2: Descriptive analytics [7]

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

Applications in manufacturing

Unit 3: Predictive analytics [7]

Multiple regression, conjoint analysis, neural networks, data clustering, Data mining, Applications in manufacturing

Unit 4: Classification techniques [7]

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

Unit 5: Prescriptive analytics [7]

Decision tree analysis, Expert system, principal component analysis, genetic algorithms, Applications in manufacturing

Unit 6: Reinforcement learning [7]

Markov chain analysis, Monte Carlo simulation, Q learning, State action reward state action (SARSA) learning

Books:

1. Acharya Seema and Chellappan, Big 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)

411088(B): Computer Integrated Design & Manufacturing

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	Term Work: 25 Marks Practical: 50 Marks

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The term work shall consist of assignments based on the following topics. Evaluation of practical will be based on Oral examination.

1. Construction of parametric solid model of any machine elements using software package.
2. Programming on CNC Lathe/Milling (student must perform one job in group of 5 students)
3. Stress-strain analysis of any machine component consisting of 1-D, 2-D elements using FEA software.
4. Simulation of a simple mechanical system

411089 (B): Industrial Robotics Lab

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

Guidelines for Laboratory Conduction:

During each lab experiment the following activities will be carried out:

1. The instructor will explain the aims & objectives of the assignments.
2. The instructor will explain the topics required to carry out the experiment.
3. The students will do the hands on as per the Lab manual & Web resources provided.
4. The students will show the results to the instructor.

Guidelines for Student's Lab Journal:

The student's Lab Journal can be assignments submitted in the form a soft copy/hard copy. In case of soft copy submission, the print out of only first page can be kept in the Journal. It should include following as applicable: Assignment No, Title of Assignment, Date of Performance, Date of Submission, Aims & Objectives, Theory, Description of data used, Results, Conclusion.

Guidelines for Lab /TW Assessment:

The oral examination will be based on the work carried out by the student in the Lab course. Suitable rubrics can be used by the internal & external examiner for assessment.

List of Laboratory Experiments:

The term work shall be based on the following Practical Sessions (Any 6 from 1 to 7, 8 is compulsory)

1. Experiment on robot configuration.
2. Experiment on robot forward kinematic analysis.
3. Experiment on robot inverse kinematic analysis.
4. Programming the robot for pick and place operation using any robot.
5. Experiment on machine vision system.
6. Selection of gripper & sensors for any one application.
7. Detail report on any one standard configuration viz. PUMA, SCARA, Stanford etc.
8. Industrial visit report on industrial applications of robots.

Virtual LAB Links:

1. **Mechanisms & Robotics Lab** http://vlabs.iitkgp.ernet.in/mr/
2. **Robotics Application Lab** https://vlab.amrita.edu/?sub=3&brch=271&sim=1642&cnt=3525
3. **Bio Inspired Robotics Virtual Lab** https://vlab.amrita.edu/?sub=3&brch=257

411092: Project Stage 2

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 06 hours / week	Pr/Or: 06	Term work: 50 Marks Oral: 100 Marks

As per submitted project phase II plan to complete it within the time schedule, the term work shall consist of:

1. Fabrication of models, machines, prototypes based on new ideas, robots and machine based on hi-tech systems and automation, experimental set-up, fabrication of testing equipment, renovation of machines, etc. Above work shall be taken up individually or in groups.

OR

Extensive analysis of some problems done with the help of a computer individually or in a group not exceeding two students.

2. A detailed report on the work done shall include project specification, design procedure, drawings, process sheets, assembly procedure and test results etc. Project may be of the following types:

i. Manufacturing / Fabrication of a prototype machine' including selection, concept, design, material, manufacturing the components, assembly of components, testing and performance evaluation.
ii. Improvement of existing machine / equipment / process.
iii. Design and fabrication of Jigs and Fixtures, dies, tools, special purpose equipment, inspection gauges, measuring instruments for machine tools.
iv. Computer aided design, analysis *of* components such as stress analysis.
v. Problems related to Productivity improvements/Value Engineering/Material Handling Systems
vi. Energy Audit of an organization, Industrial evaluation of machine devices.
vii. Design of a test rig for performance evaluation of machine devices.
viii. Product design and development.
ix. Analysis, evaluation and experimental verification of any engineering problem encountered.
x. Quality systems and management. Total Quality Management.
xi. Quality improvements, In-process Inspection, Online gauging.
xii. Low cost automation, Computer Aided Automation in Manufacturing.
xiii. Time and Motion study, Job evaluation and Merit rating
xiv. Ergonomics and safety aspects under industrial environment
xv. Management Information System.
xvi. Market Analysis in conjunction with Production Planning and Control.

OR

Computer based design / analysis or modeling / simulation of product(s), mechanism(s) or system (s) and its validation or comparison with available benchmarks / results. When a group of students is doing a project, names of all the students shall be included on every certified report copy.

Two copies of Final Project Report shall be submitted to the college. The students shall present their Final Project Phase-II report. Before the examiners. The oral examination, shall be based on the term work submitted and jointly conducted by an internal and external examiner from industry, at the end of second semester.

Format of the project report should be as follows:

1 Paper: The Project report should be typed/printed on white paper of A-4 size.

2 Typing: The typing shall be with one and half spacing and on one side of the paper.
3 Binding: The Industrial Implant Report should be submitted with front and back cover in black Hard bound, with golden embossing.
4 Margins: Left -1.25", Right -1". Top and Bottom 1"
5 Sequence of Pages:

5.1 Title page
5.2 Certificate form Institute
5.3 Completion Certificate form Industry, if sponsored.
5.4 Acknowledgement
5.5 Abstract
5.6 Index
5.7 Nomenclature and Symbols
5.8 Actual Content
5.9 Conclusion
5.10 References.

6. Front cover: The front cover shall have the following details in block capitals
i. Title at the top.
ii. Name of the candidate in the center, and
iii. Name of the Institute, Name of Industry, if sponsored and the year of submission on separate lines, at the bottom.
7. Blank sheets: No blank sheets be left anywhere in the report.
8. Project Completion Certificate:

411093: Audit Course 8: Leadership Excellence

Unit I: 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, Team leadership, Assessing effective team, Cross functional Collaboration: Introduction, definition cross functional team work, Why use cross functional teams, Desired outcomes and team types, Towards a model of cross functional team type

Unit II: Meeting and Email Etiquettes:

Managing a Meeting: Meeting agenda, Meeting logistics, Minute taking, protocols during the meeting; Duties of the chairperson, Ground rules for conducting meeting; *Effective Meeting Strategies:* Preparing for 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

Unit III: 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, New Line Publishing, ISBN: 9781844811182
2. Marc Mancini (2003) Time Management, McGraw Hill, ISBN: 978-0071406109
3. Alison Hardingham (1998) Working in Teams, CIPD Publishing, ISBN: 9780852927670