SEMESTER I

21MN01 STATISTICAL INFERENCE AND MULTIVARIATE ANALYSIS

3 1 0 4

ESTIMATION AND TESTING OF HYPOTHESES: Estimation- Point estimation, Maximum Likelihood Estimation, Bayesian estimation of parameters, Interval estimates and Confidence interval. Sampling, sampling distribution. Testing of Statistical Hypothesis: Large sample tests- Inference concerning means, variances and proportions, Small sample tests - Inference concerning means and variances, goodness of fit and independence of attributes. (10+4)

CORRELATION AND REGRESSION: Curve fitting - The Method of Least Squares - Inference Based on Least Square Estimators, Curvilinear Regression, Multiple Regression, Correlation and Multiple Linear Regression. (11+3)

DESIGN OF EXPERIMENTS: Analysis of variance technique- Completely Randomized Designs –Randomized Block Designs – Multiple Comparisons, Factorial Experimentation- Two Factor Experiments, $2^2$and 2^4Factorial Experiments. (12+4)

MULTIVARIATE ANALYSIS: Random vectors and Matrices – Mean vectors and Covariance matrices – Multivariate Normal distribution and its properties – Principal components: Population principal components – Principal components from standardized variables. (12+4)

Total L: 45 + T: 15 = 60

REFERENCES:

1. Douglas C Montgomery, and George C Runger, “Applied Statistics and Probability for Engineers”, Wiley, Sixth Edition, 2014.
2. Jay L Devore, “Probability and Statistics for Engineering and the Sciences”, Thomson and Duxbury, Singapore, Eighth Edition, Boston, 2012.
3. Richard A Johnson, and Gupta, C. B., “Miller & Freund’s Probability and Statistics for Engineers”, Pearson Education, New Delhi, Eighth Edition, 2015.
4. Richard A Johnson, and Dean W Wichern,“Applied Multivariate Statistical Analysis”, Pearson Education, Sixth Edition, New Delhi, 2013.
5. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, “Probability and Statistics for Engineers and Scientists”, Pearson Education, Ninth edition, 2012.

21MN02 ENGINEERING ECONOMY

3 0 0 3

FOUNDATIONS: Importance of engineering economy, steps in an engineering economy study, interest rate, rate of return, terminology and symbols, cash flow diagramming, economic equivalence, minimum attractive rate of return, interest factors, combining factors, nominal and effective interest rates. (5)

BASIC ANALYSIS TOOLS: Present Worth (PW) Analysis: PW analysis of equal and different-life alternatives, capitalized cost analysis,Life Cycle Costing; Annual Worth (AW) Analysis; Rate of Return (ROR) Analysis: Internal rate of return (IRR), Minimum acceptable rate of return (MARR), multiple ROR values, incremental analysis; Benefit/ Cost (B/C) analysis: B/C analysis of a single alternative, incremental B/C analysis, use of spreadsheets. (7)

REPLACEMENT ANALYSIS: Replacement and Retention Decisions:Terminology, defender and challenger with equal and unequal lives, specified study period,economic service life, analysis withzero and non-zero interest rates, individual and group replacement. (5)

BREAK-EVEN ANALYSIS: Linear break-even analysis, break-even charts, algebraic relationships, break-even point alternatives, make or buy decision,sensitivity analysis; Depreciation;Use of spreadsheets. (4)

PROBABILISTIC RISK ANALYSIS: Sources and measures of risk, project life as a random variable, Hillier model, evaluation of projects with discrete random variables; Decision trees: Deterministic and discounted decision trees,modelling and analysis of risk using decision trees; Evaluation of projects with continuous random variables, evaluation of risk and uncertainty by Monte-Carlo simulation, use of spreadsheets. (12)

PROJECT FEASIBILITY ANALYSIS: Capital investments: Importance and difficulties, types, facets of project analysis; Marketing and technical feasibilities; Financial appraisal: Means of finance, sales estimates, cost of production, profitability, projected cash flow statement, projected balance sheet, investment criteria, project cash flows, financial health indicators. (12)

Total L: 45

REFERENCES:

1. Leland Blank, Anthony Tarquin, "Engineering Economy", 8th Edition, McGraw Hill, 2018.
2. Chan S Park, "Contemporary Engineering Economics", 6th Edition, Pearson Education, 2016.
3. Chan SPark,“Fundamentals of Engineering Economics”, 3rdEdition, Prentice Hall, 2013.
4. Theusen Gerald J., FabryckyW.J., Engineering Economy, Prentice Hall, 2008.

5. James L Riggs, David D Bedworth, Sabah U Randhawa, "Engineering Economics", 4th Edition, Tata McGraw Hill, New Delhi, 2004.
6. Prasanna Chandra, "Projects: Planning, Analysis, Selection, Financing, Implementation, and Review", 9th Edition, Tata McGraw Hill, New Delhi, 2019.

21MN03 MODELING AND ANALYSIS OF MANUFACTURING SYSTEMS

3 1 0 4

MANUFACTURING SYSTEMS AND DESIGN: Types and principles of manufacturing systems, types and uses of manufacturing models, physical models, mathematical models, model uses, model building; Assembly lines - reliable serial systems; Approaches to line balancing – largest candidate rule, Kilbridge and Wester method, ranked positional weight heuristic, COMSOAL, sequencing mixed models; Transfer lines and general serial systems – paced lines with and without buffers, unpaced lines. (10)

FLEXIBLE MANUFACTURING SYSTEMS: Types of Facility layouts, advantages, limitations, systematic layout planning, layout design procedures - quadratic assignments approach, graph theoretic approach; Robotics and automated assembly; Cellular systems -Group technology, coding schemes, assigning machines to groups, production flow analysis, binary ordering algorithm, single pass heuristic, similarity coefficient method; System components – planning and control hierarchy, system design, system setup, scheduling and control, Flexible inspection system. (12)

AUTOMATED MATERIAL HANDLING AND STORAGE: Material handling principles, Equipments, Conveyor types and analysis, Automated guided vehicles and analysis; Warehousing – Analysis of Automated storage and retrieval systems, Carousal storage systems; Introduction to material handling and storage software. (11)

MODELING AND ANALYSIS OF AUTOMATED MANUFACTURING SYSTEMS: Queuing models – notations, performance measures, M/M/1 queue, M/M/s queue, batch arrival queuing systems, queues with breakdowns; Queuing networks – open and closed networks, central server model; Petrinet modeling - Classical Petrinets, transformation firing and reachability, reachability graphs, representation schemes, Timed Pertinets, Modeling of manufacturing systems. (12)

Total L: 45

REFERENCES:

1. Ronald G Askin, "Modeling and Analysis of Manufacturing Systems", John Wiley and Sons, Inc, 1993.
2. Mikell P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson Education India, 2016
3. Viswanatham N and Narahari Y "Performance Modeling of Automated Manufacturing Systems", Prentice Hall Inc., 1992.
4. Mengchu Zhou, "Modeling, Simulation and Control of Flexible Manufacturing Systems: A Petri Net Approach", World Scientific Publishing Company Pvt. Ltd., 2000.
5. Brandimarte P and Villa A, "Modeling Manufacturing Systems" Springer Verlag, Berlin, 1999.
6. Jean Marie Proth and XiaolanXie, "Petri Nets: A Tool for Design and Management of Manufacturing Systems", John Wiley and Sons, New York, 1996.

21MN04 OPERATIONS MANAGEMENT

3 0 0 3

OPERATIONS AND PRODUCTION PROCESS: Operations function, globalization, factors affecting operation management, new trends in operation management. Operations strategy – forming operation strategies, strategy deployment, world class manufacturing practices, understanding processes (4)

Types of production processes, major factors affecting process design decisions. (3)

Steps in process planning, make-or-buy decision, process analysis, automated process plan, productivity measurement, product design and process selection (4)

DESIGNING, PLANNING AND CONTROL OF OPERATIONS: Facilities layout : globalization of operations, factors affecting location decisions, location planning methods, other issues, basic layout, designing product, process layout, hybrid layout, layout design procedures- CRAFT and ALDEP; Capacity Planning : capacity and strategy, managing demand (5)

Strategic role of forecasting, components of forecasting demand, forecasting methods- time series methods, regression methods, seasonal forecasting, cyclic forecasting, accuracy of forecasts. (5)

Framework, basic strategies, approaches to aggregate planning, graphical, empirical and linear programming. (2)

INVENTORY ANALYSIS AND CONTROL: Definitions, elements of inventory management, Inventory classification & control systems - ABC, XYZ, FSN, and VED. Material management, inventory control, lot sizing techniques, inventory order policies, basic Economic Order Quantity Models, Production Quantity Model. (11)

SCHEDULING OPERATIONS and APPLICATION OF LEAN PRODUCTION SYSTEM: Scheduling and control in the job shop, priority rules and techniques, shop floor control, Gantt chart, tools of shop floor control constraints in a manufacturing system, Drum-Buffer-Rope (DBR) methodology. (4)

Philosophy of Lean Management, creating Lean Enterprise, waste elimination; JIT :Elements of JIT, Changes in the manufacturing architecture, lot-size reduction, set-up reduction through SMED, Kanban as a control tool; Production planning and control in JIT : push and pull scheduling, kanban system, design of kanban quantities; Continuous improvement : Task force for continuous improvement, quality circle, project based small group improvement activities (PBSGIA), visual control aids for improvement. (7)

Total L: 45

REFERENCES:

1. Norman Gaither and Greg Frazier, "Operations Management" by Norman Gaither and Greg Frazier; Cengage Learning 9th Edition, 2002.
2. Richard B Chase, Nicholas J Aquilano, "Production and operations management manufacturing and service", Irwin McGraw Hill,7thEdition,2004.
3. Steven Nahims, "Production and operations analysis", McGraw-Hill 3rdEdition,1997.
4. Jay Heizer and Barry Render, "Operations Management", Pearson Education India, 11th Edition, 2015.
5. Roberta S Russell and Bernard W Taylor III, "Operations Management", Wiley India Private Limited, 7thEdition, 2012.
6. Mahadevan B, "Operations Management: Theory and Practice", Pearson Education India, 2nd Edition, 2010.

21MN05 ADVANCED OPERATIONS RESEARCH

3 2 0 5

LINEAR PROGRAMMING: Review of the principles of operations research; Linear programming: Formulation of linear programming problems (LPP), Solution of LPP: Graphical and algebraic methods, simplex method and its variants, revised simplex method; Duality and sensitivity analysis. (8+8)

TRANSPORTATION AND ASSIGNMENT MODELS: Transportation model: Mathematical formulation, methods for initial basic feasible solution: North-west corner method, least cost method, Vogel's approximation method; Moving towards optimality: Stepping stone method, MODI algorithm; Trans-shipment problem. Assignment model: Mathematical formulation, Hungarian algorithm, optimality in assignment. (7+7)

INTEGER AND DYNAMIC PROGRAMMING: Integer Programming: Graphical representation of integer programming problem, Gomory's cutting plane method, branch and bound technique; Dynamic programming: One-dimensional and multi-dimensional allocation processes, case studies. (10+5)

NETWORK FLOW MODELS: Graph theory – basic definitions; Minimum-cost network flow problem, network simplex method, maximal flow problem, shortest path problem, multi-commodity flows, project networks. (10+5)

NON-LINEAR PROGRAMMING: Unconstrained extremum points; Constrained optimization problems – Lagrangean method, Kuhn-Tucker conditions; Quadratic Programming. (10+5)

Total L: 45+T: 30=75

REFERENCES:

1. Hamdy A. Taha, "Operations Research: An Introduction", Pearson Education India, 10th Edition, 2017.
2. G Srinivasan, "Operations Research: Principles and Application", PHI Learning Pvt. Ltd, 3rdEdition, 2017.
3. F. Hillier and G. Lieberman, "Introduction to Operations Research", McGraw-Hill, 8th Edition, 2004.
4. A. Ravindran, Don T. Phillips, James J. Solberg, "Operations Research: Principles and Practice", John Wiley and Sons, 2nd Edition, 1987.
5. KantiSwarup, Gupta P K and Manmohan, "Operations Research", Sultan Chand and Sons New Delhi, 2004.

21MN06 Research Methodology and IPR

vide Automotive Engineering 21AE06

21MN72 AUDIT COURSE I

vide Automotive Engineering 21AE72

21MN51 OPTIMIZATION TECHNIQUES LABORATORY

0 0 4 2

The objective of this course is to provide adequate exposure to the applications of spreadsheet/ optimization software packages for solving optimization problems. In this course, students will be provided with an orientation on the following topics.

TOPICS FOR ORIENTATION:

1. Linear Programming Problem

2. Transportation/ Transshipment Problem
3. Assignment Problem
4. Non-linear Programming Problem
5. Project Management with PERT/ CPM
6. Game Theory
7. Unconventional Optimization using GA
8. Unconventional Optimization using SA
9. Unconventional Optimization using ANN

CASE STUDY:
Explore the solution methodology of any of the optimization problems mentioned above using spreadsheet and/or optimization software.

EXPECTED OUTCOME:
The case study should be presented as a **report** that includes **problem definition, literature review, objectives, methodology, analysis and interpretation of results and conclusions** and should be submitted at the end of the semester.

Total P: 60

REFERENCES:
1. Hamdy A Taha, "Operations Research: An Introduction", 10th Edition, Pearson, 2017.
2. Ronald L Rardin, "Optimization in Operations Research", 2nd Edition, Pearson Higher Education, 2017.
3. Singiresu S Rao, "Engineering Optimization: Theory and Practice", 4th Edition, John Wiley and Sons, New Jersey, 2009.

21MN52 WORK SYSTEMS AND ERGONOMICS LABORATORY

0 0 4 2

In this course, students will be provided with an orientation on the following topics.

TOPICS FOR ORIENTATION:
1. Method study for a process.
2. Time study for a process.
3. 5S practices.
4. Line balancing using torch factory.
5. Study of Poka-Yoke principles.
6. Human Anthropometry and determination of basic metabolic rate.
7. Physical fitness testing using Ergocycle.
8. Physical fitness testing using Treadmill.
9. Measurement of noise and illumination.
10. Human postural analysis using RULA, REBA and validation using software.

CASE STUDY:
Each student is required to perform a case study that may involve the application and/or integration of one or more orientation topics.

EXPECTED OUTCOME:
The case study should be presented as a **report** that includes **problem definition, literature review, objectives, methodology, analysis and interpretation of results and conclusions** and should be submitted at the end of the semester.

Total P: 60

REFERENCES:
1. International Labour Office, "Introduction to Work Study", 4th Edition, Geneva, 1992.
2. Martin Helander, "A Guide to Human Factors and Ergonomics", 2nd Edition, Taylor and Francis, 2006.

SEMESTER II

21MN07 DISCRETE EVENT SYSTEM SIMULATION

3 0 0 3

SYSTEM SIMULATION: Introduction to Simulation, Areas of application, System and System Environment, Components of a system, Discrete and Continuous systems, Monte Carlo simulation; Steps in simulation study; Simulation of Queuing Systems - Single server and Multi-server models, Simulation of Inventory system, Simulation of Reliability problem. (10)

RANDOM NUMBER GENERATION AND TESTING: Techniques for generating random numbers- mid-square method, mid-product method, constant multiplier technique, additive congruential method, linear congruential method, combined linear congruential generators, feedback shift register generators; Tests for random numbers - Uniformity tests- Kolmogorov-Smirnov test, chi-square test; Independence tests - runs up and runs down, runs above and below the mean, Autocorrelation test, Gap test, Poker test. (12)

RANDOM VARIATE GENERATION: Inverse transform technique- Exponential distribution, Uniform distribution, Weibull distribution, Triangular distribution, Empirical continuous distribution; Discrete distributions - empirical discrete distribution, discrete uniform distribution, Poisson distribution, geometric distribution; Acceptance - rejection technique - Poisson distribution, gamma distribution; Direct Transformation for Normal and Lognormal Distributions. (11)

SIMULATION PROCEDURE: Input Modeling - Steps to build a useful model of input data, data collection, identifying the distribution with data, parameter estimation, suggested estimators, goodness of fit tests, selecting input models without data, models of arrival processes; Variance reduction techniques- Antithetic variables, calibration and validation of models; Types of simulation with respect to output analysis- Stochastic nature of output data, Measures of performance and their estimation, Output analysis for terminating simulation, Output analysis for steady state simulation, Objectives and performance measures of manufacturing systems modeling, Modeling system randomness, Sources of randomness, Machine downtime. (8)

CASE STUDIES: Study on various simulation software; Simulation of manufacturing, service and material handling systems. (4)

Total L: 45

REFERENCES:

1. Jerry Banks, John S, Carson II, Barry L Nelson and David M Nicol, "Discrete Event System Simulation", Prentice Hall Inc., 2006.
2. Law A M, "Simulation Modeling and Analysis", Tata McGraw Hill, 2008.
3. NarsinghDeo, "System Simulation with Digital Computer", Prentice Hall of India, 2007.
4. Gordon G, "Systems Simulation", Prentice Hall Ltd., 2006.
5. Francis Neelamkovil, "Computer Simulation and Modeling", John Wiley and Sons, 1987.

21MN08 SUPPLY CHAIN MANAGEMENT

3 0 0 3

SUPPLY CHAIN AND PERFORMANCE MEASURE: Definition, house of supply chain – customer satisfaction, integration, coordination - decision phases in a supply chain, objectives of SCM, examples of supply chains, supply chain drivers, supply chain performance measures; Supply chain network design in the supply chain – factors influencing the network design, framework for network design decisions, models for facility location and capacity allocation – capacitated plant location model, gravity location model, allocating demand to production facilities, simultaneous location of plants and warehouses – impact of uncertainty on network design. (11)

INVENTORY MANAGEMENT AND RISK POOLING: Single warehouse inventory model - cycle inventory – economies of scale to exploit fixed costs, quantity discounts, short term discounting, multi-echelon inventory, example problems. managing uncertainty – safety inventory in the supply chain –safety level estimation, impact of supply uncertainty, impact of aggregation, impact of replenishment policies, managing safety inventory in multi echelon supply chain, managing safety inventory in practice – product availability – optimal level, affecting factors, supply chain contracts – risk pooling – examples; Value of information – Bullwhip effect, information and supply chain technology. (12)

DISTRIBUTION NETWORK DESIGN AND STRATEGIES: Role of distribution in supply chain – distribution network design – factors influencing distribution network design. push strategy – pull strategy – Kanban replenishment systems, types, implementation, and push–pull strategy – demand driven strategy – impact of internet on supply chain strategy; Distribution networks in practice – direct shipment, cross docking, warehousing, transhipment; Framework for strategic alliance - 3PL and 4PL – retailer-supplier partnerships – distribution integration – procurement and outsourcing – benefits, make/buy decisions, E-Procurement, supplier relationship management – supplier scoring and assessment, supplier selection and contracts – E-Business and the supply chain; Design for logistics: Reverse logistics, case studies in paper and furniture industry; Supplier integration into new product development – mass customization. (11)

CUSTOMER VALUE AND GLOBAL SUPPLY CHAINS: Customer value – dimensions, strategic pricing, customer value measures, information technology and customer value – customer relationship management. Global supply chains – introduction, driving factors, risks and advantages, issues, regional differences in logistics. Information technology for supply chain **-** Goals – standardization – infrastructure – interface devices, communications, databases, system architecture – system components – integrating the supply chain information technology - DSS for supply chain management-Integrating blockchain technology within supply chain operations. (11)

Total L: 45

REFERENCES:

1. David Simchi Levi, Edith Simchi Levi, Philip Kaminsky and Ravi Shankar "Designing and Managing the Supply Chain", 3rd Edition, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2019.
2. Sunil Chopra, Peter Meindl and DharamVirKalra "Supply Chain Management: Strategy, Planning, and Operation", Pearson India Education Service Pvt Ltd, 6th Edition, 2017.
3. HartmudStadler and ChristophKilger, "Supply Chain Management and Advanced Planning: Concepts, Models, Software", Springer-Verlag, 2015.
4. N Chandrasekaran "Supply Chain Management process, system and practice" Oxford University Press, 2010.
5. A M Pagano and M Liotine, "Technology in Supply Chain Management and Logistics: Current Practice and Future Applications", Elsevier, 2019.
6. David F Ross, "Introduction to E-Supply Chain Management", CRC Press, 2003.

21MN82 AUDIT COURSE II

vide Automotive Engineering 21AE82

21MN61 SYSTEM SIMULATION LABORATORY

0 0 4 2

In this course, students will be provided with an orientation on the following topics.

TOPICS FOR ORIENTATION:

1. Use of Programming Language for Random Number generation by Mid-Square, Midpoint and Congruential method.
2. Use of Programming Language for Random variate generation for different distributions.
3. Testing random numbers for Uniformity.
4. Testing random numbers for Independence.
5. Fitting statistical distributions to data.
6. Simulating a queuing model.
7. Layout analysis and optimization.
8. Scheduling using Simulation.
9. Value stream mapping.
10. Manufacturing and service system simulation

CASE STUDY:

Each student is required to perform a case study that involvessimulation of selected manufacturing/ service system.

EXPECTED OUTCOME:

The case study should be presented as a **report** that includes **problem definition, literature review, objectives, methodology, analysis and interpretation of results and conclusions** and should be submitted at the end of the semester.

Total P: 60

REFERENCES:

1. David Kelton, Rondall P Sadowski and David T Sturrock, “Simulation with Arena”, 3rd Edition, McGraw Hill, 2003.
2. Jerry Banks, John S Corson II, BarryL Nelson, David MNicol, Discrete Event Systems Simulation, 5th Edition, Pearson Education, 2010.

21MN62 DATA ANALYTICS LABORATORY

0 0 4 2

In this course, students will be provided with an orientation on the following topics.

TOPICS FOR ORIENTATION:

1. Histograms and Normality testing
2. Variable control charts
3. Attribute control charts
4. Process Capability analysis
5. Failure Modes and Effects Analysis
6. Reliability Analysis
7. Linear, Multiple and Non-linear Regression
8. Experimental design (Classical)
9. Experimental design (Taguchi)
10. Response Surface Methodology

CASE STUDY:

Each student is required to perform a case study that involves a detailed and systematic analysis and interpretation of experimental/ process data.

EXPECTED OUTCOME:

The case study should be presented as a **report** that includes **problem definition, literature review, objectives, methodology,**
analysis and interpretation of results and conclusions and should be submitted at the end of the semester.

Total P: 60

REFERENCE:

1. Douglas C Montgomery, “Introduction to Statistical Quality Control”, 8th Edition, John Wiley, 2019.

21MN63 INDUSTRIAL VISIT AND TECHNICAL SEMINAR
vide Automotive Engineering 21AE63

SEMESTER – III

21MN71 PROJECT WORK – I
vide Automotive Engineering 21AE71

SEMESTER – IV

21MN81 PROJECT WORK – II
Vide Automotive Engineering 21AE81

PROFESSIONAL ELECTIVES

21MN21 LEAN SIX SIGMA IN MANUFACTURING AND SERVICE

3 0 0 3

CONCEPTS OF LEAN SIX SIGMA: Lean Principles, eight major wastes; Six-Sigma: Concept, methodology, definition, origin, common terms; Five laws of lean six sigma, Methodology - DMAIC, DMADV, Project selection; Six Sigma roles and responsibilities; Six sigma training plan; Team: stages,characteristics of effective teams, Lean Six-sigma (LSS) metrics: DPMO calculation; Quality cost: cost of poor quality, cost of quality; Roadmap for implementation: Plan, issues, management strategies. (10)

DEFINE AND MEASURE PHASES: Customer identification,voice of customer(VOC),VOC data collection, Critical to quality(CTQ); Value Stream Mapping; SIPOC; Project charter; Types of measures;Types of data; Applications of old and new 7 QC tools; Measurement system analysis; Process capability analysis, comparison of statistical softwares;Introduction to Data analytics. (12)

ANALYSE PHASE: Inferential and Descriptive Statistics; Patterns of Variation; Normality Analysisusing python, multi-vari analysis; Hypothesis testing for Normal Data: Selection and application problems; Failure mode and effects analysis - applications; Analysis of Lean Wastes. (11)

IMPROVE AND CONTROL PHASES: Process redesign principles; Generating improvement alternatives; Quality Function Deployment (QFD); Theory of Inventive Problem Solving (TRIZ); Introduction to design of experiments; Lean waste elimination methods, cycle time reduction; Cost/benefit analysis; Process scorecard: Control Plan. Introduction to IoT data acquisition. (12)

Total L: 45

REFERENCES:

1. Jay Arthur, “Lean Six Sigma – Demystified”, Tata McGraw Hill Companies Inc, 2011.
2. Juran Institute, JuranGlobal's Lean and Six Sigma Reference Guide and Tool Kit, CreateSpace Independent Pub, 2014.
3. Robert Dirgo, “Look Forward Beyond Lean and Six Sigma”, Cengage Learning, 2014.
4. Anil Maheswari, “Data Analytics”, McGraw-Hill Education, 2017.
5. Thomas Pyzdek, “Six Sigma Handbook: Complete Guide for Greenbelts, Blackbelts and Managers at All Levels”, Tata McGraw Hill Companies Inc,2003.
6. Donald W Benbow and Kubiak T M, “Certified Six Sigma Black Belt Handbook”, Pearson Education, 2007.

21MN22 LOGISTICS STRATEGIES AND DISTRIBUTION MANAGEMENT

3 0 0 3

LOGISTICS, DISTRIBUTION AND PLANNING FOR LOGISTICS: Introduction to logistics and distribution- Integrated logistics and the supply chain- Integrated logistics and the supply chain- Customer service and logistics- Channels of distribution – Key issues and challenges for logistics. Planning framework for logistics -Logistics processes -Supply chain segmentation- Logistics network planning - Logistics management and organization - Manufacturing and materials management. (12)

WAREHOUSING AND STORAGE: Principles of warehousing Storage and handling systems (palletized and non-palletized) – Order picking and replenishment- Receiving and dispatch - Warehouse design- Warehouse management and information. (11)

FREIGHT TRANSPORT AND OPERATIONAL MANAGEMENT: International logistics: modal choice - Maritime transport - Air transport - Rail and intermodal transport- Road freight transport: vehicle selection, vehicle costing and planning and resourcing – International transportation systems in Global perspective. Cost and performance monitoring- Benchmarking- Information and communication technology in supply chain- Outsourcing: services and decision criteria, the selection process – Outsourcing management- Security and safety in distribution - Logistics and the environment. (12)

MAINTENANCE LOGISTICS: Human factors – Maintenance staffing: Learning curves – Simulation – Maintenance resource

requirements: Optimal size of service facility – Optimal repair effort – Maintenance planning and scheduling – Spare parts planning. (10)

Total L: 45

REFERENCES:

1. Alan Rushton,PhilCroucher and Peter Bake, "The Handbook of Logistics and Distribution Management", Kogan Page, 6th Edition, 2017.
2. Jean-Paul Rodrigue, Claude Comtois and Brian Slack, "The geography of transport systems", New York, 3rd Edition, 2013.
3. Andrew K.S.Jardine, and Albert H.C.Tsang, "Maintenance, Replacement and Reliability", Taylor and Francis, 2006.
4. BikasBadhury, and S.K.Basu, "Tero Technology: Reliability Engineering and Maintenance Management", Asian Books, 2003.
5. Seichi Nakajima, "Total Productive Maintenance", Productivity Press, 1993.
6. Donald Waters, "Global Logistics and Distribution Planning: Strategies for Management", Kogan Page, 2003.

21MN23 COSTING AND PRODUCT ANALYSIS

3 0 0 3

ELEMENTS OF COSTING: Elements of cost – estimation – differences – types of costing – cost classification – depreciation – different methods; Types of cost**:** Labour cost – direct, indirect - labour variances - material cost - direct, indirect - material cost variances with examples, overhead cost. Elements in over heads, machine hour rate, apportioning methods - variance – examples (11)

ACTIVITY BASED COSTING AND TARGET COSTING: Introduction - traditional approach, comparison- examples– activity-based management; introduction to target costing, market driven, product driven and component driven target costing. (10)

COST CALCULATION AND ANALYSIS: Cost calculation for machined components, welding, casting and forged components plastic molded, powder metallurgy parts – illustrations – calculation of sales cost- cost of refection – case studies – use of computers in cost estimation; Cost analysis techniques: Analytical, graphical and incremental methods for single and multi-variable situations – learning curves. (12)

PRODUCT DEVELOPMENT AND PROCESS SELECTION: New products, new product strategy - market definition, idea generation - introduction to the design process – quality function deployment - forecasting sales potential - product engineering and markets, monopoly, competitive; Manufacturing planning**:** Selection of optimum process, standardization. - Process capability analysis - break even analysis - application and area of use - problems - multi - product analysis. (12)

Total L: 45

REFERENCES:

1. Glen L Urban and John R Hauser, "Design and Marketing of New Products", Prentice Hall, New Jersey, 2004.
2. Banga T R, Sharma S C, "Mechanical Estimating and Costing (Including Contracting and Process Planning)", Khanna Publishers, 2015.
3. Kannappan D, Ag Augustine, Paranthaman D, "Mechanical Estimating and Costing", Tata McGraw Hill, New Delhi, 2003.
4. Narang G B S and Kumar V, "Production and Costing", Khanna Publishers, Fourth edition, 2014.

21MN24 PROJECT MANAGEMENT

3 0 0 3

PERCEPTION OF PROJECT MANAGEMENT: Defining project success, the talent triangle, roles of project stakeholders, classification of projects, concurrent engineering, evolution and elementary definitions of PM, causes of project failures, the stage-gate process, project lifecycles, methodologies of PM, systems thinking, types of organizational structures, seven impediments to PM maturity, organizational chart of a project, prevalent mistakes in PM, case studies on management functions and communications management. (11)

CONFLICT RESOLUTION AND PLANNING: Types of conflicts - superior, subordinate, and functional;modes of resolution, case studies on conflict handling and resolution, Variables in PM - predicting project success, best practices adopted in PM; Planning – business case, assumptions and objectives, lifecycle phases and milestones, project specifications and selection, management cost and control system, work planning authorization, project plan, charter, verification and validation, audits. (10)

SCHEDULING, COSTING AND METRICS: Fundamentals of network, Graphical Evaluation and Review Technique (GERT), dependencies, slack time,network replanning, PERT/CPM and crash times, probabilistic schedules, variable time estimates, PERT beta and triangular models, precedence networks, probability of project completion, burn down and burn up charts, Gantt Chart, Pertmaster Metrics; PM software; Pricing and Estimates – pricing strategies, types of estimates, systems pricing, life-cycle costing, the time value of money and discounted cash flow, Net Present Value (NPV), Internal Rate of Return (IRR), comparing IRR, NPV, and payback; Cost control - the Earned Value Measurement System (EVMS), the cost overrun dilemma, case studies on cost control; Metrics - project management information systems, Key Performance Indicators (KPIs), value-based metrics. (16)

RISK, CONTRACTS AND QUALITY MANAGEMENT: Certainty, risk, and uncertainty, risk management process, qualitative and quantitative risk analysis, responding, monitoring and controlling risk; Contracts – Procurement planning, types of contracts

vs risks; Quality management – concepts, the cost of quality, the seven quality control tools, the Project Management Maturity Model (PMMM); Case studies on project delays and successful project completions. (8)

Total L: 45

REFERENCES:

1. Erik Larson and Clifford Gray, "Project Management: The Managerial Process", McGraw-Hill Education, 8th Edition, 2020.
2. Te Wu, "Optimizing Project Management", CRC Press, 1st Edition, 2020.
3. Pradeep Pai, "Project Management", Pearson Education, 1st Edition, 2019.
4. Gary L. Richardson and Brad M. Jackson, "Project Management Theory and Practice", CRC Publications, 3rd Edition, 2019.
5. Robert KWysocki, "Effective Project Management: Traditional, Agile, Extreme", John Wiley and Sons, 8th Edition, 2019.
6. Harold Kerzner, "Project Management: A Systems Approach to Planning, Scheduling, and Controlling", John Wiley and Sons, 12th Edition, 2017.

21MN25 SEQUENCING AND SCHEDULING

3 0 0 3

SINGLE AND PARALLEL MACHINE SCHEDULING: Scheduling as a function and theory, scheduling problem, sequencing - objective, constraints, difference between sequencing and scheduling; Single machine models -Characteristics, terminology, theorems, SPT and EDD sequences, minimizing in - process inventory, mean flow time, weighted mean flow time, number of tardy jobs and mean tardiness, Hodgson's algorithm, Wilkerson -Irwin algorithm, applications of dynamic programming and branch and bound techniques, minimizing total cost, non-simultaneous arrivals, dependent jobs, sequence dependent set up time, use of assignment model, heuristic solutions; Parallel Machine Models -Minimizing make span, independent jobs- McNaughton's algorithm, heuristic procedures, minimizing weighted mean flow time, jobs- Hu's algorithm, Muntz-Coffman algorithm. (12)

FLOW SHOP AND JOB SHOP SCHEDULING: Flow shop-Permutation schedule, Johnson's problem, branch and bound algorithms, dominance properties for make span problems, heuristic approaches, flow shops without intermediate queues, other performance measures; Job shop -Types of schedules, schedule generation - branch and bound approach, heuristic procedures, integer programming approach. (11)

RESOURCE CONSTRAINED PROJECT SCHEDULING AND SIMULATION: Extending job shop model - extending project model, integer programming approach - heuristic methods; Project Scheduling -Logical constraints, network constructions, temporal analysis, probabilistic network analysis, time/cost trade-off, resource allocation; Simulation -Elements of simulation models, reducing mean flow time, meeting due dates, case studies. (12)

RESOURCE SCHEDULING: Interval scheduling, reservations and timetabling -Reservation without slack, reservation with slack,timetabling with workforce, operator constraints - Case study; Planning, scheduling and timetabling in transportation - Tanker andaircraft scheduling, train scheduling; workforce scheduling -Day-off scheduling,shift scheduling- cyclic staffing problem,operator scheduling in a callcenter. (10)

Total L: 45

REFERENCES:

1. Baker K, "Introduction to Sequencing and Scheduling", John Wiley and Sons, 2009.
2. Michael L Pinedo, "Planning and Scheduling in Manufacturing and Services", Springer Science and Business Media, 2009.
3. Dileep R. Sule,Production Planning and Industrial Scheduling, CRC Press, 2007
4. Richard Walter Conway, William L. Maxwell, Louis W. Miller , "Theory of Scheduling", Addison-Wesley, Mass., 2003.

21MN26 VALUE ENGINEERING

3 0 0 3

CONCEPTS OF VALUE ENGINEERING (VE): Introduction, types of values, types of functions, function identification, feature function matrix, function analysis; Elements of costs, cost allocation to functions.Worth analysis: Meaning and importance of worth, evaluation of worth, guide lines to find worth. (11)

TECHNIQUES OF VE: General tools: Brain storming, Gordon technique, feasibility ranking, morphological analysis, ABC analysis, probability approach, make or buy decision; Special tools: Function-cost- worth analysis, FAST: technically oriented FAST, customer oriented FAST, weighted evaluation method. (11)

VE TEAM DYNAMICS: Team constitution, selection of team members; Team dynamics: team transformation, interpersonal relationship; Conduct of VE project study, task flow diagram, pre-study phase, workshop phase and post-study phase. (10)

VALUE ENGINEERING JOB PLAN: Orientation phase, information phase, speculation phase, analysis phase: evaluation of alternatives, cost benefit analysis, recommendation phaseand implementation phase - operational and financial audit, applications ofVE Job Plan. (13)

Total L: 45

REFERENCES:

1. Kassa A O, "Value Analysis and Engineering Reengineered", Taylor and Francis, 2016.
2. Mukhophadhyaya A K, “Value Engineering Mastermind: From Concept to Value Engineering Certification”, Sage Publications Pvt. Ltd., New Delhi, 2014.
3. Del Younker, "Value Engineering Analysis and Methodology", 1st Edition, CRC Press, 2003.
4. Richard J Park, “Value Engineering – A Plan for Invention”, CRC Press, 1999.

21MN27 ENTERPRISE RESOURCE PLANNING

3 0 0 3

FUNDAMENTALS OF ERP SYSTEMS: ERP an overview, Enterprise an overview, ERP as integrated management information system; Evolution of ERP, benefits of ERP, ERP vs. traditional information systems; MRP II model. (10)

BUSINESS PROCESS REENGINEERING (BPR): Need and challenges, management concerns about BPR, BPR to build the business; Model for BPR, Basic constituents for BPR, and Selection criteria for BPR – Implementation of BPR based on the process, Methodology for implementing BPR. (10)

ERP PACKAGES: Analysis of ERP packages, survey of Indian ERP packages - coverage, performance and cost; Extended ERP (ERP II) -Advanced planning systems, business intelligent systems; IoT module for ERP system with Cloud computing – ERP case studies: Manufacturing and education domain. (12)

ERP IMPLEMENTATION: ERP – implementation, lifecycle, implementation methodology, hidden costs in implementation, Top management concerns, organizing the implementation, vendors, consultants and users, project management and monitoring, issues in customizing ERP systems for organizations, need for training; Functions of Finance & Costing – Materials Management, Production Planning, Human Resource, Plant Management, Quality Management, Sales and Distribution modules. (13)

Total L: 45

REFERENCES:

1. Alexis Leon, “Enterprise Resource Planning”, Tata McGraw-Hill Publishing Company, 4th Edition, 2019.
2. Rajesh Ray,” Enterprise Resource Planning Paperback”, Tata McGraw-Hill Publishing Company, 2017.
3. Michael W. Pelphrey, “Directing the ERP Implementation: A Best Practice Guide to Avoiding Program Failure Traps While Tuning System Performance”, CRC Press, 2015.
4. Alexis Leon,” ERP Demystified”, Tata McGraw-Hill Publishing Company, 3rd Edition, 2014.
5. Marianne Bradford, “Modern ERP: Select, Implement, and Use Today's Advanced Business Systems”, 3rd Edition, 2014.

21MN28 HUMAN FACTORS AND ERGONOMICS

3 0 0 3

FOUNDATIONS OF HUMAN FACTORS ENGINEERING (HFE) AND POSTURAL ANALYSIS: Evolution of HFE, compatibility, Hawthorne experiments, sociotechnical systems theory, FMJ vs FJM trend, attempts to humanize work, Participative design of work equipment, case studies using HFE checklists and task analysis, risk assessment and design tools, Oxenburgh productivity model, case studies on ergonomics in industry, analysis of postural stability, risk factors for musculoskeletal injury, problems – whole body impact, collisions, shocks and spinal compression, measurement of musculoskeletal pain in the workplace. (12)

RELIABILITY AND HUMAN ERROR: Human-system integration, system variables, causes of human error and taxonomies, evaluation of human reliability, computational methods for human reliability analysis - THERP, SHERPA, TAFEI, HCR, ATHEANA, and CREAM, human information processing model. (12)

ANTHROPOMETRY AND WORKSTATION DESIGN: Types of anthropometric data in ergonomics, statistical analysis of anthropometric variables, workstation design to fit a target population, cost benefit analysis and trade-offs, scaling techniques – RASH, design of workstation and customized products using anthropometric data, system integration. (12)

PERCEPTION, SAFETY AND ENVIRONMENTAL DESIGN: Display of visual, auditory, and tactual Information, occupational accident trends, structural risk heuristics, domino models, fault-tree analysis, Cusp catastrophe model, Swiss Cheese model of risk management, measures for accident prevention, design of micro and macro environments, theory of defensible space, sick building syndrome, initiation to OSHA, NIOSH and BIS ergonomic standards, case studies delineating remedial ergonomic intervention. (9)

Total L: 45

REFERENCES:

1. Robert S Bridger, “Introduction to Human Factors and Ergonomics”, CRC Press, 2018.
2. Robert W Proctor, Trisha Van Zandt, “Human factors in simple and complex systems”, CRC Press, 2018.
3. Stephen J Guastello, “Human Factors Engineering and Ergonomics: A Systems Approach”, CRC Press, 2013.
4. Steven J Landry, Mark R Lehto, “Introduction to Human Factors and Ergonomics for Engineers,CRC Press, 2013.
5. Karl HE Kroemer, Hiltrud J Kroemer, Katrin E Kroemer-Elbert, “Engineering Physiology”, Springer, 2020.
6. Andre Liem, “Prospective Ergonomics”, Wiley, 2017.

21MN29 TOTAL PRODUCTIVE MAINTENANCE

3 0 0 3

FOUNDATIONS OF TOTAL PRODUCTIVE MAINTENANCE (TPM): Definition and distinctive features, developmental stages, zero defects and TPM, relationship between TPM, Terotechnology and Logistics; Overall Equipment Effectiveness**:** Six major losses, OEE metrics, process average method, weighted process average method, total equipment effectiveness equipment performance (TEEP), financial aspects of OEE, data acquisition for OEE. (10)

AUTONOMOUS MAINTENANCE (JISHU HOZEN): Specific goals for equipment, operators, technicians, detecting minor machine defects, setting standards, typical examples, machine tags, and one-point lessons –typical examples. Autonomous Maintenance**:** Seven levels - initial cleaning, preventive cleaning machines, cleaning and lubrication standard, general inspection, autonomous inspection, process disciple, independent autonomous maintenance. (12)

PREVENTIVE MAINTENANCE (PM): Elements of preventive maintenance, PM checklist, PM schedules, inspection specification, replacement part numbers, PM procedure, part logs, quality checks, PM Master-plan. (11)

TPM IMPLEMENTATION: Introduction of TPM to the organization, creation of organization structure, Basic TPM policies and aids, master plan, Kick start. TPM implementation stages: Small group activities, implementing AM, establishing planned maintenance, training and education, developing equipment management program, perfecting TPM implementation – raising TPM levels, case studies. (12)

Total L: 45

REFERENCES:

1. Andrew K.S.Jardineand Albert H.C.Tsang, “Maintenance, Replacement and Reliability”, Taylor and Francis, 2006.
2. BikasBadhuryandS.K.Basu, “Tero Technology: Reliability Engineering and Maintenance Management”, Asian Books, 2003.
3. Hansen R C, “Overall Equipment Effectiveness: A Powerful Production Maintenance Tool”, Industrial Press, USA, 2001.
4. Robinson C J and Ginder A P, “Implementing TPM: The North American Experience”, Productivity Press, USA, 1995.
5. Seichi Nakajima, “Total Productive Maintenance”, Productivity Press, 1993.

21MN30 HUMAN RESOURCE MANAGEMENT
vide Lean Manufacturing 21ML26

21MN31 SUSTAINABILITY MANAGEMENT
vide Lean Manufacturing 21ML36

21MN32 ENTREPRENEURSHIP DEVELOPMENT
vide Lean Manufacturing 21ML22

21MN33 INDUSTRIAL INTERNET OF THINGS
vide Computer Integrated Manufacturing 21MC25

OPEN ELECTIVE THEORY COURSES (One to be opted)

21MN91 BUSINESS ANALYTICS IN PRACTICE
vide Computer Integrated Manufacturing 21MC91

21MN92 LIFE CYCLE ASSESSMENT AND ECO – DESIGN
vide Computer Integrated Manufacturing 21MC92

21MN93 SYSTEMS ENGINEERING AND MANAGEMENT
vide Computer Integrated Manufacturing 21MC93