MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT /CENTER: Department of Mechanical Engineering

M. Tech. : Industrial Engineering

Semester. I

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21MET521	Advance Optimization Techniques	Lecture	PC	3	3	0	0
2	21MET522	Applied Statistics	Lecture	PC	3	3	0	0
3	21MET523	Work System Design	Lecture	PC	3	3	0	0
4		Program Elective-I	Lecture	PE	3	3	0	0
5		Program Elective-II	Lecture	PE	3	3	0	0
6		Program Elective-III	Lecture	PE	3	3	0	0
					18			

Semester. II

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21MET524	Advanced Operations Planning & Control	Lecture	PC	3	3	0	0
2	21MEP525	Ergonomics Lab	Laboratory	PC	1	0	0	2
3	21MET526	Quality System Engineering	Lecture	PC	3	3	0	0
4	21MEP527	Simulation and Optimization Lab	Lecture	PC	1	0	0	2
5	21MET528	Supply Chain Management	Lecture	PC	3	3	0	0
6		Program Elective-IV	Lecture	PE	3	3	0	0
7		Program Elective-V	Lecture	PE	3	3	0	0
					17			

Semester. III

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21MED621	Dissertation	Research	PC	6	0	0	6
2	21MES622	Seminar	Seminar	PC	4	0	0	4
					10			

Semester. IV

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	21MED623	Dissertation	Research	PC	12	0	0	12
					12			

*PC= Program Core; PE= Program Elective; OE=Open Elective

List of Program Elective (PE)				
Course Code	Course Title	Course Category	Credit	L-T-P
21MET812	Artificial Intelligence in Manufacturing Systems	**PE**	**3**	**3-0-0**
21MET813	Human Factor Engineering	**PE**	**3**	**3-0-0**
21MET814	Machine Learning in Manufacturing Systems	**PE**	**3**	**3-0-0**
21MET815	Manufacturing Strategy	**PE**	**3**	**3-0-0**
21MET816	Product Design and Development	**PE**	**3**	**3-0-0**
21MET817	Productivity Engineering	**PE**	**3**	**3-0-0**
21MET818	Project Management	**PE**	**3**	**3-0-0**
21MET819	Reliability Engineering	**PE**	**3**	**3-0-0**
21MET820	Service System Design	**PE**	**3**	**3-0-0**
21MET821	Six Sigma & Lean Manufacturing	**PE**	**3**	**3-0-0**
21MET822	Smart Manufacturing Systems	**PE**	**3**	**3-0-0**
21MET823	Sustainable Manufacturing	**PE**	**3**	**3-0-0**
21MET824	System Modling and Simulations	**PE**	**3**	**3-0-0**

Credit Distribution among different types of courses is as under

Type of courses	Credits	Range as per scheme
Program core (PC)	20	18-21
Program elective (PE)	15	15-21
Open elective (OE)	0	0-3
Research project, seminar dissertation	22	16-24
Total	57	54-60

Program coordinator

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre   : Department of Mechanical Engineering

Course Code   : 21MET521

Course Name   : Advanced Optimization Techniques

Credits   : 3   **L -** 3   **T -** 0   **P -** 0

Course Type   : Program Core

Prerequisites : None

Course Contents

Linear Programming, Integer Programming, Mixed Integer Programming, Combinatorial Optimization, Non-linear Optimization, Dynamic Programming: Stochastic and deterministic, multistage optimization problems, Heuristic Programming: Local search heuristic, continuous variable heuristic, Metaheuristic: Genetic Algorithm.

Recommended Readings

Text Books: -

1. Operations research: applications and algorithms, Wayne L. Winston, Vol. 3. Belmont^ eCalif Calif: Thomson/Brooks/Cole, (2004).
2. Introduction to Management Operation Research and Management Science, J.L Rigss, Mc Graw-Hill Book Company, (1975)
3. Operations Research: A Practical Introduction, Ghaith Rabadi, Taylor and Francis (2018)

Reference books: -

1. Hamdy A Taha, Operations Research: An Introduction, Pearson Education/PHI, 8/E, 2007.
2. Singiresu S Rao, Engineering Optimization: Theory and Practice, New Age International (P) Limited, Third Edition, 1996
3. F S Hillier and G J Lieberman, Introduction to Operations Research, TMH, 8/E, 2006.
4. Winston,W.L., Operations Research: Applications and Algorithms, Thomson Learning, 4th Edition, 2004.

Online/E resources: -

1. Fundamental of operation research (NPTEL)
2. Operation Research (1) & (2) (Coursera)

Course Code	:	21MET522							
Course Name	**:**	**Applied Statistics**							

Credits	**:**	3	**L -**	3	**T -**	0	**P -**	0
Course Type	:	Program Core						
Prerequisites	:	none						

Course Contents

Fundamentals of probability theory and statistical inference used in engineering and applied science, descriptive statistics. Probability models, random variables, expectations, moment generating functions and its properties, conditional probability, useful discrete and continuous distributions. Statistical inference, confidence interval estimation, point estimation, case studies. Concept of null hypothesis, testing of hypothesis, goodness of fit tests, linear regression, non-parametric test procedure, Properties of probability distributions and their applications in Q-ing, reliability, quality control and simulation, law of large numbers, central limit theorem and its applications, case studies, Industrial applications, curve fitting and other techniques of estimation, introduction to software in statistics.

Recommended Readings

Text Books: -

1. Principles of Applied Statistics. Cox, D.R., and Donnelly, C.A., (2011). Camridge Press.
2. Probability and Statistics for Engineers. Johnson, R.A., (2011). 8th Ed., PHI Learning.

Course Code : <u>**21MET523**</u>

Course Name : <u>**Work System Design**</u>

Credits : <u>3</u>   **L -** <u>0</u>   **T -** <u>0</u>   **P -** <u>0</u>

Course Type : Program Core

Prerequisites : None

Course Contents

Introduction of Work System Design, Concept of Productivity, Factors Influencing Productivity, Productivity Measurement Models, Productivity Improvement Techniques, Numerical Problems on Productivity; Work Study: Basic Concept, Concept of Work Content, Techniques of Work Study, Human Aspects of Work Study; Method Study: Basic Concept; Recording Techniques: Charts and Diagrams; Principles of Motion Economy; Micro-Motion Study; Therbligs; SIMO Charts; Memo-Motion Study, Cycle graph and Chrono-Cycle Graph; Work Measurement: Basic Concept, Techniques of Work Measurement, Performance Rating, Allowances; Time Study, Work Sampling, Numerical Problems; Synthetic Data, PMTS; Ergonomics: Basic Concept, Industrial Ergonomics, Man-Machine-Environment Interaction System; Physiological and Psychological Aspects of Ergonomics; Anthropometry, Positioning of Displays and Controls, Effect of Noise, Illumination, Vibration, Temperature and Humidity on Workplace Design; Case Studies**.**

Recommended Readings

Reference books:

1. Mark S.Sanders, and Ernest J. McCormick, —Human factors in Engineering and Design, McGraw Hill,   New York.
2. Davind J.Oborne, Ergonomics at Work, John Willy and Sons Ltd., New York.
3. International Labour Organisation, Introduction to Work Study,‖ Universal Book Corporation, New Delhi.
4. Francis and White,‖Facilities Location-an analytical approach,‖ McGraw Hill, New York
5. R.S.Bridger, Introduction to Ergonomics, McGraw Hill, New York.

Online/E resources: -

1. Work System Design (NPTEL)

Course Code	:	**21MET524**
Course Name	:	**Advanced Operations Planning & Control**

Credits	:	3	**L -**	3	**T -**	0	**P -**	0
Course Type	:	Program Core						
Prerequisites	:	None						

Course Contents

Introduction to Management of Production Systems, Waiting line models, Process planning, Layout designing, Advanced Forecasting models, Inventory control under uncertainty, Aggregate Planning with mixed strategies, advanced planning and scheduling systems, Theory of constraints.

Recommended Readings

Text Books: -

1. Integrated Production control Systems, Bedworth, David, D & James E Bailey, John Wiley & Sons.

Reference books: -

1. Production Planning & Inventory Control, Narsimhan S. L., Mcleavy, Billirgton, PHI.
2. Operations Management, G.Cachon, C. Terwiesch, Mc Graw Hill

Online/E Resources: -

1. https://www.managementstudyguide.com/production-planning-and-control.htm
2. https://www.yourarticlelibrary.com/production-management/production planning/production-planning-and-control-business/69520

Course Code	:	**21MEP525**
Course Name	:	**Ergonomics Lab**

Credits	:	1	**L -**	0	**T -**	0	**P -**	2
Course Type	:	Program Core						
Prerequisites	:	Work System Design (MET-653)						

Course Contents

Method to improve the assembly and dis-assembly of a Bolt, Methods Improvement - Assembling pins on cardboard, Stop watch time study and Work sampling exercises, Calibration of an individual using Tread Mill as a loading-device, Measurement of anthropometrics data and analysis of data, Audiometric examination a through pure tone audiogram of a subject using portable audiometer in a portable audiometric testing cabin, Measurement of the respiratory parameter of an individual, Spirometry Test, Acoustic measurement.

Recommended Readings

Reference Books

1. Mark S. Sanders, and Ernest J. McCormick, ―Human factors in Engineering and Design, McGraw Hill, New York.
2. Davind J.Oborne,‖Ergonomics at Work,‖ John willy and Sons Ltd., New York.
3. International Labour Organisation,‖Introudction to Work Study,‖ Universal Book Corporation, New Delhi.
4. W. T. Singleton, -The Body at Work: Biological Ergonomics, Cambridge University Press, United Kingdom.

Online/E resources: -

1. https://nptel.ac.in/courses/112/107/112107249/

Course Code	:	21MET526					
Course Name	:	**Quality System Engineering**					

Credits	:	3	**L -**	3	**T -**	0	**P -** 0

Course Type : Program Core

Prerequisites : None

Course Contents

Basic Concepts of Quality And its Connotations, Evolution of TQM, Contribution of Quality Gurus, Quality Cost, Quality Circles, Characteristic and Roles of a Successful Quality Leader, Voice of Customer and Retention of Customer, Employee Involvement, Teamwork, Performance Appraisal and Rewards, Juran Trilogy, Kaizen, Quality Awards: Malcolm Baldrige National Quality Award, Deming Prize, Benchmarking, Seven QC Tools, ISO 9000 Series Of Standard, ISO14000+ Certifications, Environmental Management System, Concept of Six Sigma, Poka Yoke, Statistical Process Control and Process Capability, Acceptance Sampling Plans for Attribute and Variable, Reliability, Failure Mode and Effect Analysis, House of Quality, Quality Function Deployment.

Recommended Readings

Text Books: -

1. Grant, E.L.& Leavenworth R.S. Statistical Quality Control, McGraw Hill.
2. Juran J.M & Gryna F.M. Quality planning and analysis, McGraw Hill.
3. Koru Ishikawa, Guide to Quality Control, Asian Productivity Organization.
4. Amitava Mitra –Fundamentals of Quality Control & Improvement, Mcmillan Publishing Company.

Course Code	:	**21MEP527**
Course Name	:	**Simulation and Optimization Lab**

Credits	:	1	**L -**	0	**T -**	0	**P -**	2
Course Type	:	Program Core
Prerequisites	:	None

Course Contents

Introduction to Management of Production Systems, Waiting line models, Process planning, Layout designing, Advanced Forecasting models, Inventory control under uncertainty, Aggregate Planning with mixed strategies, advanced planning and scheduling systems, Theory of constraints.

Recommended Readings

Text Books: -

1. WITNESS software handbook

Online/E resources: -

1. https://www.managementstudyguide.com/waiting-line-management.htm
2. https://www.sortly.com/blog/what-are-the-3-major-inventory-management-techniques/

Course Code	:	**21MET528**
Course Name	:	**Supply Chain Management**

Credits	:	3	**L -** 0	**T -** 0	**P -** 0

Course Type : Program Core

Prerequisites : None

Course Contents

Role and evolution of Supply Chain Management, Competitive Strategy and supply chain strategies; Strategic fit, System View, Supply chain drivers and metrics, Distribution of networks, Network design, Supply chain risk and risk mitigation strategies. Sales and operations planning, Co-ordination in a supply chain, Sales and operations planning, Co-ordination in a supply chain, Cycle inventory, managing uncertainty in a supply chain, Product availability, Transportation mode and network, Sourcing decisions in a supply chain, sustainability and the supply chain, solving supply chain problems with spreadsheet.

Recommended Readings

Text Books: -

1. Supply Chain Management: Strategy, Planning and Operation. Sunil Chopra & Peter Meindl, Pearson Education. Third Edition 2007. ISBN: 0-13-208608-5
2. Designing and Managing the Supply Chain. Simchi-Levi, David, Philip Kaminsky, and Edith Simchi-Levi. 2nd ed. New York, NY: McGraw-Hill, 2003. ISBN: 0071410317. (SKS)

Reference books: -

1. Factory Physics. Hopp, Wallace and Mark Spearman. 2nd ed. Boston, MA: Irwin, 2000. ISBN: 0256247951. (HS)
2. Supply Chain Logistics Management. Donal J. Bowersox, David J. Closs, M. Bixby Cooper. Tata McGraw Hill, 2nd edition. 2007. ISBN: 0070667039; 9780070667037
3. Business Logistics and Supply Chain Management. Ronald H. Ballou. Pearson Education, 5th Edition, 2004. ISBN: 9788131705841

Course Code	:	21MED621
Course Name	:	Dissertation

Credits	:	6	L - 0	T - 0	P - 6

Course Type : Program Core

Prerequisites : To carryout technical and practical issues related to industry.

Course Contents

Identify the research problem; Formulate problem and select appropriate research method(s); Search relevant literature and identify research gap.

Course Code	:	21MES622
Course Name	:	Seminar

Credits	:	4	L -	0	T -	0	P -	4
Course Type	:	Program Core						
Prerequisites	:	To carryout technical and practical issues related to industry						

Course Contents

Identify technical issues related to industrial engineering; Outline annotated bibliography; Search the existing literature; Identification of research problem; Prepare a well-organized report; Describe, interpret and analyze technical issues.

Course Code	:	**21MED623**
Course Name	:	**Dissertation**

Credits	:	12	**L -** 0	**T -** 0	**P -** 12

Course Type : Program Core

Prerequisites : The students should have knowledge of industrial core courses.

Course Contents

Identify a problem; Review of literature to identify gaps; Develop a model, experimental set-up and/or computational techniques necessary to meet the objectives; Prepare a report; Publishing papers in peer reviewed journals/conference proceedings.

Course Code	:	**21MET812**
Course Name	:	**Artificial Intelligence in Manufacturing Systems**

Credits	:	3	**L -** 3	**T -** 0	**P -** 0

Course Type : Program Elective

Prerequisites : None

Course Contents

Introduction to artificial intelligence, problem formulation, solving problem by searching, AI in production system, Fuzzy logic, Neural networks, decision trees, population-based search, machine learning, supervised learning algorithm, unsupervised learning algorithms, performance assessment of machine learning algorithms.

Recommended Readings

Text Book: -

1. Artificial Intelligence: A Modern Approach, Second Edition, Russell, S. and Norvig, P., Pearson Education (2009).

Reference book: -

1. Machine Learning, First Edition, Dutt, S., Chandramouli, S. and Das, A.K. Pearson Education (2018).

Online resources: -

1. https://towardsdatascience.com/how-can-artificial-intelligence-be-applied-in-manufacturing8662eaaea999#:~:text=In%20addition%20to%20facilitating%20the,can%20help%20organizations%20design%20products.&text=These%20algorithms%20then%20explore%20all,iteration%20and%20improve%20upon%20it
2. https://www.seebo.com/machine-learning-ai-manufacturing/

Course Code	:	**21MET813**
Course Name	:	**Human Factor Engineering**

Credits	:	3	**L -**	3	**T -**	0	**P -**	0

Course Type : Program Elective

Prerequisites : Work System Design (MET-653)

Course Contents

Introduction to Human Factors and Ergonomics; Man-Machine System and its Components; Anatomy, Posture, and Body Mechanics; Stress and Strain, Metabolism, Measure of Physiological Functions- Workload and Energy Consumption. Design and Evaluation Tools; Visual Sensory System; Auditory, Tactile, and Vestibular Systems; Cognition; Display and Control Design. Anthropometry and Workplace Design; Static Work Design; Repetitive Task Design; Manual Handling Tasks and Hand Tools; Work Physiology; Environmental Conditions; Mental Workload and Human Error; Safety and Accident Prevention. Assessment of Occupational Exposure to Noise, Heat Stress and Dust. Effect of Vibration/ Noise, Temperature; Lighting in Physical Environment; Industrial Product Design, Illumination and Dust on Human Health and Performance; Case Studies.

Recommended Readings

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,2000.
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., 1993.

Course Code	:	21MET814
Course Name	:	**Machine Learning in Manufacturing Systems**

Credits	:	3	**L -**	3	**T -**	0	**P -**	0
Course Type	:	Program Elective
Prerequisites	:	None

Course Contents

What is Artificial Intelligence (AI), what is Machine Learning (ML), difference between AI and ML, types of ML, applications of ML, types of data in ML, exploring structure of data, data pre-processing, Model selection (predictive and descriptive models), feature transformation, feature sub-set selection, Bias, variance and complexity, confusion matrix, model accuracy measures Classification steps, k-nearest neighbor, decision tree, random forest model, support vector machines, logistic regression, factor analysis, principle component analysis, sentiment analysis, understanding biological neuron, single layer feed forward network, back propagation algorithm, learning process in ANN, deep learning

Recommended Readings

Text books: -

1. Machine Learning, Dutt, S., Subramanian, C. and Das, A.K., Pearson (2019).

Reference books: -

1. Machine Learning in Production, Kellaher, A. and Kellaher, A., Pearson (2019).
2. Principles of Applied Statistics, Cox, D.R. and Donnelly, C.A, Cambridge Press (2011).
3. Probability and Statistics for Engineers 8th Ed., Johnson, R.A. PHI Learning (2011).

Online resources: -

1. https://towardsdatascience.com/machine-learning-in-manufacturing-17c95290b1f6

Course Code	:	21MET815						

Course Name	:	**Manufacturing Strategy**						

Credits	:	3	**L -**	3	**T -**	0	**P -**	0
Course Type	:	Program Elective						
Prerequisites	:	none						

Course Contents

Manufacturing Strategy: Relevance and concept, strategic issues in manufacturing, content and process aspect of manufacturing strategy, Manufacturing output, Operations Strategy, International innovations in manufacturing, Concept of world-class manufacturing organization, 6 Ps of Manufacturing, Skinners' view and Hayes and Wheelwright framework of Manufacturing Strategy, Alternative paradigm of manufacturing strategy, Some generic manufacturing strategies. Competitive priorities - quality, delivery, flexibility and cost, improvement activities, Trade-offs in manufacturing priorities, focused manufacturing, Implementation of manufacturing policies, world class manufacturing, Interface between manufacturing and marketing, inter-relationship among manufacturing Managers, suppliers, customers and competitors. Human resource issues, Recent manufacturing Strategies, Assemble-to-order (ATO), Make to Order (MTO), Lean Manufacturing and Sustainable Manufacturing. Case Studies. Developing a manufacturing strategy, Understanding markets, The concept of order winners and qualifiers, Basic Characteristics and Specific Dimensions of Order Winners and Qualifiers, Enlightened View of Manufacturing, Manufacturing Strategy Taxonomy: Some evidences from China, Quality Management and Manufacturing Excellence, Total Quality Management and Manufacturing Excellence, Critical success factors for World Class Manufacturing, Value Added Engineering, Flexible Manufacturing system, Concept of Focus with respect to Manufacturing Strategy, Toyota production System I, Toyota production System II, World Class Manufacturing and India, Achieving World Class Status.

Recommended Readings

Reference Books: -

1. Voss C. A, Manufacturing strategy: Process and content, 1992, London: Chapman & Hall.
2. Steve Brown, Manufacturing the Future: Strategic Resonance for Enlightened Manufacturing, 2000, Prentice Hall
3. Terry Hill, Manufacturing strategy, 1989, Homewood, IL

Course Code	:	21MET816

Course Name	:	**Product Design and Development**

Credits	:	3	**L -**	3	**T -**	0	**P -**	0

Course Type : Program Elective

Prerequisites : none

Course Contents

Product Development Process, Customer Need Analysis, New Product Adoption- Target Specification, Concept Generation, Concept Selection, Concept testing, Product Architecture, Industrial Design, Design for Manufacturing, Design Structure Mapping, Robust Design, Prototyping, Product Development Economics.

Recommended Readings

Text Books: -

1. Product Design and Development by Karl T Ulrich, Tata McGraw Hill Education

Reference books: -

1. Product Design Method and Practices by Henry W. Stoll CRC Press

Online/E resources: -

1. https://www.lisaadelhi.com/product-development-vs-product-design/
2. https://www.designrush.com/trends/product-design-development

Course Code	:	**21MET817**
Course Name	:	**Productivity Engineering**

Credits	:	3	**L -**	3	**T -**	0	**P -**	0

Course Type : Program Elective

Prerequisites : none

Course Contents

Basic definitions and scope of productivity. Significance of productivity in economic development. Productivity Evaluation - Expression for total productivity change, the productivity Evaluation Tree. Productivity planning. Long/short term productivity planning. Productivity measurement at national level. Diversity of productivity concepts. Partial productivity, total productivity and total factor productivity, Productivity measurement model. Total productivity models. Causes of low productivity in organization. Strategies for productivity improvement. Analytical productivity improvement model. Productivity improvement techniques: Technology based, materials based, product based, employee based and task based. Productivity in service industries; Case studies.

Recommended Readings

Reference Books: -

1. Scot Sink, Productivity Management: Planning Measurement and Evaluation. Control and Improvement – John Wiley, N.Y.
2. Sumnath, David J., Productivity Engineering & Management, Mc.Graw Hill N.Y.

Course Code	:	**21MET818**
Course Name	:	**Project Management**

Credits	:	3	**L -**	3	**T -**	0	**P -**	0
Course Type	:	Program Elective						
Prerequisites	:	None						

Course Contents

Introduction to project management, Project life cycle, Need identification and project proposals, Project feasibility, Project selection. Project definition, Work Breakdown Structure and its integration with organizational structure, Cost and time estimates. Precedence relations, Network development, Basic CPM calculations, PERT procedure and simulation, Project crashing, Resource levelling and resource allocation, project monitoring and control, earned value management system. Project organizations and teams, Critical chain project management, project management software.

Recommended Readings

Reference Books: -

1. Jack R. Meredith and Samuel J. Mantel Jr., Project Management, A Managerial Approach, 6th Edition, John Wiley & Sons.
2. Gray Clifford F. and Erik W. Larson. 2011. Project Management: The Managerial Process. 5th edition. McGraw-Hill Irwin Publishers
3. J.D. Wiest and F.K. Levy, Management Guide to PERT/CPM with GERT/PDM/DCPM John, Prentice Hall.
4. Harold Kerzner, Project Management: A systems approach to project planning scheduling and controlling. John Wiley and Sons Inc.
5. Arun Kanda., Project Management – A Life Cycle Approach, PHI Learning.

Course Code	:	**21MET819**
Course Name	:	**Reliability Engineering**

Credits	:	3	**L -**	3	**T -**	0	**P -**	0
Course Type	:	Program Elective						
Prerequisites	:	none						

Course Contents

Failures of engineering systems, causes of failures, bathtub curve, component reliability from test data, logic diagrams, Markov's model, reliability improvement techniques, Objectives of life testing, types of tests, accelerated life test, stress combinations, step-stress methods, moment estimation, maximum likelihood estimator, Determination of various failure distributions, Non-parametric methods, reliability growth testing, AMSAA growth model, Economic issues, Manufacturer's cost, customer's cost, reliability achievement cost, reliability utility cost models, depreciation cost models, availability cost model, Reliability program, management policies and decisions, reliability management by objectives, reliability group, reliability data, managing people for reliability

Recommended Readings

Text Books: -

1. Reliability and Maintainability Engineering, Charles E. Ebeling, Tata McGraw Hill, 2000.

Reference books: -

1. Reliability Engineering, E. Balagurusamy, by Tata McGraw-Hill Publishing Company Limited, 2002.
2. "Practical Reliability Engineringt", Patrick D T o'connor, John-Wiley and Sons inc, 2002.

Online/E resources: -

1. https://towardsdatascience.com/tagged/reliability-engineering
2. https://en.wikipedia.org/wiki/Reliability_engineering

Course Code	:	**21MET820**
Course Name	:	**Service System Design**

Credits	:	3	**L -**	3	**T -**	0	**P -**	0
Course Type	:	Program Elective
Prerequisites	:	none

Course Contents

Basic concepts of service operations, Understand service processes, SERVQUAL, their basic rules and details, Understand the relationship between supplier and customer, concepts of quality, hygiene and demand management, Concept of performance in service operations, capacity management, queue management, Learn key aspects of service recovery.

Recommended Readings

Text Books: -

1. Service Operations Management, Improving Service Delivery, Robert Johnston and Graham Clark. Pearson Education India, New Delhi, 2nd edition.

Reference books: -

1. Operations Management along the supply chain, Bernard Taylor and Roberta Russell. Wiley India, 7th edition

Online/E resources: -

1. https://www.informit.com/articles/article.aspx?p=2170657&seqNum=4
2. https://www.interaction-design.org/literature/topics/service-design

Course Code : **21MET821**

Course Name : **Six Sigma & Lean Manufacturing**

Credits : 3   **L -** 3   **T -** 0   **P -** 0

Course Type : Program Elective

Prerequisites : none

Course Contents

Lean - Evolution & Steps, Lean - Specify Value - Quality at Source, 5S Concepts, 5S Implementation, Lean – Identify Value Stream - Process Mapping, Why is Inventory bad, Process Layouts, Lean - Make It Flow - Setup Time Reduction, Hejunka, Total Productive Maintenance, Lean - Pull - Visual Controls, Lean - Pull - Push & Pull Systems, Lean - Pull – JIT, Six Sigma (basics and history of the approach, methodology, and focus), the application of Six Sigma in production and service industries, Relationship of Six Sigma and Lean Management, linking Six Sigma project goals with organizational strategy; Basic description and application of tools of the DMAIC methodology.

Recommended Readings

Text Books:-

1. The Tactical Guide to Six Sigma Implementation, S Patel, CRC Press (2017)
2. The Ten Commandments of Lean Six Sigma: A Guide for Practitioners, Jiju Antony, Laux Chad, Cudeny Elizabeth, Emerald Group Publishing (2019).
3. Lean Six Sigma for Small and Medium Sized Enterprises: A practical guide, Jiju Antony, Sekar Vinodh, E.V. Gijo, CRC Press (2017)

Reference books:-

1. Becoming Lean - Inside Stories of U.S. Manufacturers, Jeffrey K. Liker, Productivity Press, Portland, Oregon
2. The Six Sigma Handbook, Third Edition, Thomas Pyzdek & Paul Keller, McGrawHill
3. Lean Six Sigma by Michael L George by McGraw Hill
4. The Certified Six Sigma Green Belt Handbook, Second Edition: Roderick A. Munro, Govindarajan Ramu and Daniel J. Zrymiak,ASQ Quality Press
5. Implementing Six Sigma: Smarter Solutions Using Statistical Methods: Forrest W. Breyfogle, John Wiley & Sons
6. James P.Womac, Daniel T Jones, Daniel Rose; The Machine That Changed the World

Online/E resources:-

1. Six Sigma (NPTEL)
2. Introduction a Lean Six Sigma (Coursera)

Course Code	:	**21MET822**
Course Name	:	**Smart Manufacturing Systems**

Credits	:	3	**L -** 3	**T -** 0	**P -** 0
Course Type	:	Program Elective			
Prerequisites	:	none			

Course Contents

Introduction to Industry 4.0, IIoT and Smart manufacturing. Sensing & actuation devices, Sensor based controls, Communication and networking, Networking architecture and standards, Cloud and Fog computing, Big data and analytics. Robotic in automation, Additive manufacturing, Augmented reality and Digital Twins, Data security issues. Production planning and control in smart manufacturing, Predictive maintenance, Smart product, Smart logistics, Sustainability and smart manufacturing; Design principles and roadmap for smart manufacturing. Use cases.

Recommended Readings

Reference Books

1. Arsheep Bahga and Vijay Madisetti, Internet of Things: A Hands-On Approach
2. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress.
3. Sudip Misra, Chandana Roy and Anandarup Mukherjee, Introduction to Industrial Internet of Things and Industry 4.0. CRC Press

Course Code : **21MET823**

Course Name : **Sustainable Manufacturing**

Credits : 3   **L -** 3   **T -** 0   **P -** 0

Course Type : Program Elective

Prerequisites : None

Course Contents

Concept of sustainability, manufacturing, operations, processes, practices, Resources in manufacturing, Evolution of Sustainable Manufacturing, Basic Statistical Concepts for Sustainable Manufacturing Analysis, Circular Business Models, Linkage between Lean and Sustainable Manufacturing, Environmentally Conscious Quality Function Deployment (ECQFD), Extended Producer Responsibility (EPR) policy. Fundamentals of Life Cycle Assessment (LCA Life Cycle Cost Analysis, Life Cycle Assessment Product Life Cycle Management: Energy and Mass, Green Supply chain: Carbon footprints in transportation, Whole value chain, and lifecycle of products/services, from the development, to the end of life stages. Machining for eco-efficiency. Implementation of lean methods: validating requirements. Managing materials for sustainability.

Recommended Readings

Text books: -

1. Sustainable Manufacturing: Concepts, Tools, Methods and Case Studies", Dr.S. Vinodh, CRC Press; 1st edition (27 October 2020)
2. "Sustainable Manufacturing: Challenges, Solutions and Implementation Perspectives", Rainer Stark, GüntherSeliger, JérémyBonvoisin, Springer; 1st edition(2017)
3. "Sustainable Manufacturing: Shaping Global Value Creation", GüntherSeliger, Springer-Verlag Berlin Heidelberg, 1st edition (2012)

Reference books: -

1. "Sustainable Manufacturing for Industry 4.0: An Augmented Approach", K. Jayakrishna, Vimal K.E.K., S. Aravind Raj, Asela K. Kulatunga, M.T.H. Sultan, J. Paulo Davim, CRC Press (November 2, 2020)
2. "Sustainable Manufacturing", Kapil Gupta,KonstantinosSalonitis, Elsevier 2021, 1st Edition
3. "Sustainable Manufacturing – Principles, Applications AND Directions", P.N.Rao, 28thNational Convention of Production Engineers CRC Press, 1st edition, (2013),

Online/E resources: -

1. Sustainability through Green Manufacturing Systems: An Applied Approach(NPTEL)
2. Simulation and modeling of natural processes (Coursera)

Course Code	:	21MET824
Course Name	:	**System Modelling and Simulations**

Credits	:	3	**L -** 3	**T -** 0	**P -** 0
Course Type	:	Program Elective
Prerequisites	:	none

Course Contents

Simulation of Manufacturing and Material handling system, Statistical model in simulation, Random-Number Generation, Random Variate Generation. Continuous, discrete, Monte Carlo technique, agent-based, system dynamics, games, and virtual worlds with suitable examples from industrial engineering problems, Verification and validation of simulation data. Comparison and evaluation of alternative system designs.

Recommended Readings

Text books: -

1. Theory of modelling and simulation: discrete event & iterative system computational foundations, P. Bernard Zeigler, Muzy Alexandre, Kofman Erensto, Academic Press (2018).
2. Discrete-event modelling and simulation: theory and applications. A Garbirel Wainer, Mosterman Pieter, CRC Press (2018).
3. Modeling and Simulation of systems using MATLAB and Simulink, Devendra Kumar Chaturvedi, CRC Press (2018)

Reference books: -

1. Jerry Banks and John, S. Carson II, 'Discrete – Event System Simulation', Prentice Hall Inc., NewJersey, 1984.
2. Geoffrey Gordon, 'System simulation', Prentice Hall, NJ, 1978. Law, A.M. and W.D. Keltor, 'Simulation modelling analysis', McGraw Hill, 1982.

Online/E resources: -

1. Modelling and Simulation of discrete event system (NPTEL)
2. Simulation and modeling of natural processes (Coursera)