Annexure-7

CURRICULUM

FOR

Integrated Dual Degree Programme (M.Tech-PhD Industrial and Production Engineering)

महात्मा ज्योतिबा फुले
रुहेलखण्ड विश्वविद्यालय, बरेली

DEPARTMENT OF MECHANICAL ENGINEERING
FACULTY OF ENGINEERING AND TECHNOLOGY
M. J. P. ROHILKHAND UNIVERSITY,
BAREILLY-243006 (U.P.) INDIA

Integrated Dual Degree M.Tech-PhD Programme

in

Industrial and Production Engineering

Year-1

Semester-I (Odd Semester)

Sr. No.	Subject Code	Subjects	Teaching Schedule			Credits
			L	T	P	
1		Advanced Engineering Mathematics	3	1	0	4
2	MME-1003C 55552	Statistics for Decision Making	3	1	0	4
3	MME-1005C 55553	Research Methodology	3	1	0	4
4	MME-1007C 55554	Experimental Design Techniques	3	1	0	4
5	MME-1009E 55555/ MME-1011E 55556	Advance Heat Transfer (Elective-I) Advanced Manufacturing Process (Elective-I)	3	1	0	4
6	MME-1001P 65551	Industrial Engineering Lab-I	0	0	2	2
7	MME-1013P 65552/ MME-1009P 65553	Simulation Lab/ Heat Transfer Lab	0	0	2	2
		Total				**24**

Semester-II (Even Semester)

Sr. No.	Subject Code	Subjects	Teaching Schedule			Credits
			L	T	P	
1	MME-1016C 55571	Metal Cutting Principle and Manufacturing Technology	3	1	0	4
2	MME-1018C 55572	Total Quality Management	3	1	0	4
3	MME-1020C 55573	Operations Management	3	1	0	4
4	MME-1022C 55574	Robotics and Automation	3	1	0	4

5	MME-1024E 55575/ MME-1026E 55576/ MME-1028E 55577	Operation Research (Elective-II) Computer Aided Design and Manufacturing (Elective-II) Additive Manufacturing (Elective-II)	3	1	0	4
6	MME-1030P 65571	Industrial Engineering Lab- II	0	0	2	2
7	MME-1026P 65572	Computer Aided Manufacturing Lab	0	0	2	2
		Total				**24**

Electives-II

Subject Code	**Paper Code**	**Subject**
MME-1024E	55575	Operation Research
MME-1026E	55576	Completed Aided Design and Manufacturing
MME-1028E	55577	Additive Manufacturing

Year-2

Semester-III (Odd Semester)

Sr. No.	Subject Code	Subjects	Teaching Schedule			Credits
			L	T	P	
1	MME-1103P 65573	Dissertation-I*	0	0	20	18
2	MME-1105P 65574	Seminar	0	0	2	4
		Total				**22**

Semester-IV (Even Semester)

Sr. No.	Subject Code	Subjects	Teaching Schedule			Credits
			L	T	P	
1	MME-1102P 65575	Dissertation-II*	0	0	22	22
		Total				**22**

It is desirable that candidate should publish at least 02 papers in national/International Journal/ conferences.

Sub. Code **Advanced Engineering Mathematics** **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Develop the ability to analyze boundary value problems and apply solution techniques like separation of variables, the method of characteristics, and Fourier series to solve PDEs.

CO 2: Develop a deep understanding of vector calculus concepts like divergence, curl, gradient, and line, surface, and volume integrals, and apply these concepts to problems in electromagnetism, fluid mechanics, and continuum mechanics.

CO 3: Students will be able to apply numerical methods (e.g., finite difference, finite element, and Runge-Kutta methods) to solve ordinary and partial differential equations where analytical solutions are difficult or impossible to obtain.

CO 4: Enhance problem-solving skills, critical thinking, and analytical techniques to break down complex engineering problems into solvable components using advanced mathematical concepts.

Unit-01: Linear Algebra: Introduction to vector space, linear independence, solution of simultaneous linear systems, uniqueness and existence, Algebraic eigenvalue problem, similarity transformation, Introduction of linear transformation, Calculus: Differential geometry, parametric representation, Grad, Div and Curl, introduction to tensor algebra, equation of line, plane, surface, Line integral, path independence, Divergence theorem, Stokes theorem, Green's theorem in a plane.

Unit-02: Ordinary Differential Equation: First order equations, integrating factor, orthogonal trajectories, Existence and uniqueness, Second order equations with constant coefficients, The Cauchy-Euler equation, Method of undetermined coefficients, variation of parameters, matrix method, Sturm-Liouville problems, trigonometric Fourier series.

Unit-03: Integral Transform: Fourier series, Fourier integral, Fourier and Laplace transform, standard rules, Dirac-delta and Heaviside function, convolution, solution of ODEs.

Unit-04: Partial differential equation: Linear equations, superposition, separation of variable, Second order wave equation, Unsteady heat conduction equation, Laplace equation.

Text Books and References:

1. David Kincaid and Ward Cheney, "Numerical Analysis: Mathematics of Scientific Computing'', AMS, 2009.
2. Richard L. Burden and J. Douglas Faires, Numerical Analysis, Cengage Learning India Private Ltd.
3. M. K. Jain, S.R.K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publications, 2008.
4. K. E. Atkinson, "An Introduction to Numerical Analysis", Wiley, 2nd Edition, 1989.
5. S.D. Conte, Carl de Boor, "Elementary Numerical Analysis: An Algorithmic Approach'', SIAM, 2018.

Subject Code MME-1003C | **Statistics for Decision Making** | **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Students will develop a strong foundation in basic statistical concepts, including types of data, data types, scales of measurement, and the role of statistics in decision-making processes.
CO 2: Understand the fundamentals of probability theory, including basic probability rules, conditional probability, and Bayes' theorem.
CO 3: Understand and apply techniques for estimation, point estimation, and interval estimation to make data-driven decisions and evaluate the uncertainty associated with those decisions.
CO 4: Understand how to interpret test results, make decisions based on statistical significance, and communicate findings effectively in the context of decision-making.
CO 5: Apply correlation analysis to measure the strength and direction of relationships between variables, and learn how to assess causality versus correlation in decision-making contexts.

Unit 1: Fundamentals of Probability Theory and Descriptive Statistics:

- Descriptive Statistics: Mean, median, mode, variance, standard deviation, and data visualization.
- Probability Theory: Basics of probability, probability models, random variables, probability mass function (PMF), probability density function (PDF).
- Conditional Probability & Bayes' Theorem: Concepts of conditional probability, independence, and Bayes' Theorem.

Unit 2: Probability Models and Random Variables:

- Discrete and Continuous Distributions: Properties of common distributions like Binomial, Poisson, Normal, Exponential, etc.
- Expectations and Moments: Mean, variance, and higher moments; moment generating functions and their properties.
- Law of Large Numbers & Central Limit Theorem: Their importance in probability and statistical applications.

Unit 3: Statistical Inference and Estimation Techniques:

- Point Estimation: Methods of moments, maximum likelihood estimation.
- Confidence Intervals: Construction and interpretation for population parameters.
- Case Studies: Applications of estimation methods in real-world engineering and applied sciences problems.

Unit 4: Hypothesis Testing and Goodness of Fit:

- Concept of Null Hypothesis & Alternative Hypothesis: Types of errors (Type I & II), significance level, p-value.
- Testing of Hypotheses: Z-test, t-test, chi-square tests.
- Goodness of Fit Tests: Chi-square test for distributions.
- Non-Parametric Tests: Wilcoxon test, Mann-Whitney U test.

Unit 5: Regression, Curve Fitting, and Software Applications:

- Linear Regression: Simple and multiple regression analysis, interpretation of coefficients.
- Curve Fitting and Estimation Techniques: Least squares method and other curve fitting approaches.
- Software in Statistics: Introduction to statistical software like R, Python (Numpy, Pandas) and others for data analysis and modeling.
- Industrial Applications: Quality control, reliability analysis, and simulation.

Recommended Books:

1. **William Feller**, *An Introduction to Probability Theory and Its Applications*, Vol. 1, Wiley, 3rd Edition, 1968.
2. **M. K. Jain, S.R.K. Iyengar**, *Probability and Statistics for Engineers*, New Age International, 2nd Edition, 2011.
3. **M. R. Spiegel**, *Mathematical Statistics*, Schaum's Outline Series, McGraw-Hill, 4th Edition, 2014.
4. **A. M. Mood, F. A. Graybill, and D. C. Boes**, *Introduction to the Theory of Statistics*, McGraw-Hill, 3rd Edition, 2007.
5. **M. K. Jain, S. R. K. Iyengar**, *Statistical Methods for Engineers and Scientists*, New Age International, 2nd Edition, 2014.

Subject Code MME-1005C **Research Methodology** **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Develop the ability to choose suitable data collection techniques (e.g., surveys, interviews, focus groups, observations) based on the research objectives.
CO 2: Understand how to interpret research data, draw conclusions, and validate findings, ensuring they are consistent with the research objectives and questions.
CO 3: Understand the distinction between qualitative and quantitative research methods and be able to identify when to apply each approach depending on the research objectives and data types.
CO 4: Understand how to assess the credibility and reliability of sources and use academic databases to gather relevant research material.
CO 5: Learn how to identify research gaps and propose new areas for exploration or future studies based on existing research limitations or emerging trends.

Unit 1: Research Methodology: An introduction; meaning of research; objective of research; motivation in research; types of research, research approaches; significance of research, research methods v/s methodology; research and scientific method.

Defining the Research Problem: What is problem; selecting the problem; necessity of defining the problem, Hypothesis: Types and their formulation, Uses of Internet resources in selecting problem research.

Unit 2: Research Design: Meaning of the research design; need for research design; feature of a good design; important concept relating to research design; different research design; basic principles of experimental designs; important experimental Designs; developing a research plan.

Sampling Design: Census and sample survey; Implication of sample design; Steps in sampling design; Criteria for selecting a sampling procedure, Sampling & Non-sampling error, Sample size calculation.

Unit 3: Methods of Data Collection: Selection for appropriate method for data collection; collection of primary data; online data collection tools; collection of data through questionnaires/schedules/other methods; collection of secondary data;

Unit 4: Processing and Analysis of Data: Processing operations; Elements/types of analysis; Univariate Analysis (measures of central tendency; measures of dispersion; measures of asymmetry (Skewness& Kurtosis); Bi-variate Analysis (measures of relationship; simple regression analysis); Multiple correlation and regression; partial correlation; Association in the case of attributes; Introduction to Multivariate analysis: Confirmatory Factor Analysis (CFA) , Structural Equation Modeling (SEM)

Unit 5: Interpretation and Report Writing: Meaning of interpretation; why interpretation? Analysis Writing, Discussion Writing, Techniques of interpretation, precautions in interpretation; Significance of Report Writing; Bibliography and References, Online Referencing using Internet Resources.

Recommended Books:

1. **C. R. Kothari**, *Research Methodology: Methods and Techniques*, New Age International, 2nd Edition, 2004.

2. **V. K. Gupta**, *Research Methodology and Quantitative Techniques*, Atlantic Publishers, 2015.
3. **Ranjit Kumar**, *Research Methodology: A Step-by-Step Guide for Beginners*, Sage Publications, 4th Edition, 2019.
4. **C. R. Kothari**, *Research Methodology: Methods and Techniques*, New Age International, 2nd Edition, 2004.
5. **Robert K. Yin**, *Case Study Research and Applications: Design and Methods*, Sage Publications, 6th Edition, 2018.
6. **Susan B. Kinnear and James R. Taylor**, *Marketing Research: An Applied Approach*, McGraw-Hill, 10th Edition, 2011.
7. **Robert K. Yin**, *Case Study Research and Applications: Design and Methods*, Sage Publications, 6th Edition, 2018.

Subject Code MME-1007C **Experimental Design Techniques** **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Students will gain foundational knowledge of experimental design concepts, including variables, controls, and different types of experimental setups.
CO 2: Students will learn specific techniques such as Randomized Block Designs, Latin Square Designs, and Factorial Designs, and understand their applications and limitations.
CO 3: Students will develop skills in statistical methods for analysing experimental data, including ANOVA (Analysis of Variance), regression analysis, and hypothesis testing.
CO 4: Students will be able to apply factorial design methods and response surface methodology (RSM) to optimize processes and improve outcomes.

Unit 1: Introduction to Designed Experiments, Importance and Need for Experimental Design, Basic statistics (ii) ANOVA (iii) Regression

Unit 2: Experimental designs-
(i) RCBD (ii) Latin square (iii) BIBD (iv) CCD (iv) Regression Modelling (v)Taguchi Approach.

Unit 3: Factorial designs-
(i) Full factorial designs (ii) 2 k factorial designs (iii) Blocking and confounding in 2 k factorial designs (iv) 2 k - p factorial designs.

Unit 4: Response surface methodology-
(i) Method of steepest ascent (ii) Analysis of second order responses (iii) Multiple responses

Unit 5: **Robust design-**
(i) Crossed array design (ii) Combined array design.

Textbook: Montgomery, Design and Analysis of Experiments, 7th Edition.

Reference Books:

1. Roy, Ranjit K, Design of Experiments Using the Taguchi Approach: 16 Steps to Product and Process Improvement, John Wiley & Sons, Inc 2001.
2. G. Casella, S. Fienberg, and I. Olkin, Statistical Analysis of Designed Experiments, Third Edition, Springer Science Business Media, LLC, 2009.
3. Klaus Hinkelmann and Oscar Kempthorne, Design and Analysis of Experiments (Volume 2: Advanced Experimental Design), John Wiley & Sons, Inc, 2005.
4. J. Antony, Design of Experiments for Engineers and Scientists, Elsevier Science & Technology Books, 2003.
5. G. E. P. Box and N. R. Draper, Response Surfaces, Mixtures, and Ridge Analyses, John Wiley & Sons, Inc, 2007.

Subject Code MME-1009E **Advance Heat Transfer (Elective-I)** **LTP (310)**

Course Outcomes (COs)

At the end of the course, the student will be able to:

CO 1: Students will gain advanced knowledge of conduction, convection, and radiation, including the mathematical models that describe these processes.

CO 2: Students will develop the ability to analyze systems involving combined modes of heat transfer, including conduction-convection, convection-radiation, and phase-change phenomena.

CO 3: Students will understand the design and optimization of heat exchangers, including shell-and-tube, plate, and microchannel heat exchangers, and will apply various models to assess their performance.

CO 4: Students will apply advanced heat transfer principles to solve real-world engineering problems, such as in thermal management of electronics, energy systems, aerospace, and manufacturing processes.

Unit 1: Understand the basic modes of heat transfer, Analysis of steady state situation in conduction for plane wall, cylinder and sphere. Study the transient (time dependent) conduction and solving problems of 1-d with explicit and implicit scheme, Understand the basic of radiation.

Unit 2: Derivation of governing equation for three-dimensional transient heat conduction problems. Two-dimensional steady state heat conduction. Transient one-dimensional heat conduction in finite length bodies

Unit 3: Newton's law of cooling-Derivation of energy equation- Self-similar solution for laminar boundary flow over a flat plate – energy integral method for laminar boundary layer flow over a flat surface-Laminar internal flows-thermally fully developed flows Gratz problem - Natural convection over a vertical flat plate: similarity solutions and energy integral method- natural convection in enclosures-mixed convection-Turbulent flow and heat transfer: Reynolds averaged equations-Turbulent boundary layer flows – The law of wall-integral solutions. Convective mass transfer.

Unit 4: Convection with phase change: Pool boiling regimes- Condensation: drop-wise condensation-Laminar film condensation over a vertical surface.

Unit 5: Radiative heat transfer: Black body radiation-radiative properties of non-black bodies surface radiation heat transfer in enclosures with grey diffused walls and non-grey surfaces. Calculation of radiation exchange between black and grey body and concept of gas radiation.

Reference Books:

1. Fundamentals of engineering Heat and mass transfer - R.C. SACHDEVA – New Age International
2. Heat transfer – Ghoshdastidar – oxford university Press – IInd edition.
3. Heat and mass transfer – R.K. Rajput
4. Fundamental of heat transfer and mass transfer – Incropera and Dewitt – John Wiley. Publication.

5. Fundamentals of Heat and Mass Transfer, Incropera and Dewitt, Sixth Edition, John Wiley.
6. Convection Heat Transfer, A Bejan, John Wiley.
7. Convective Heat and Mass Transfer, W M Kays and M E Crawford, McGraw-Hill publishing Company.
8. Thermal Radiation Heat Transfer, J Siegel and R Howell, Elsevier.

Subject Code MME-1011E | **Advanced Manufacturing Process (Elective-I)** | **LTP (310)**

Course Outcomes (COs)

At the end of the course, the student will be able to:

CO 1: Students will gain a comprehensive understanding of advanced manufacturing techniques, including additive manufacturing, precision machining, advanced welding, and non-traditional machining (e.g., EDM, ECM, and laser cutting).

CO 2: Gain proficiency in advanced non-traditional manufacturing processes like Electrical Discharge Machining (EDM), Electrochemical Machining (ECM), Laser Beam Machining (LBM), and Ultrasonic Machining (USM).

Unit 1: USM and AJM

Ultrasonic Machining (USM): Basics, mechanics, Shaw's model, Process parameters; Abrasive Jet Machining (AJM): Basics, process parameters, MRR, Components

Unit 2: Electrochemical Machining (ECM)

ECM Basics: Electrochemistry, Debye-Huckel theory, ECM process, MRR estimation, electrode potential; ECM Dynamics: Kinematics, tool shape, electrolyte flow design, Insulation design, defects in ECM; Electrochemical Grinding and Drilling: Basics and process parameters

Unit 3: Thermal Processes (EDM, EBM)

Electro-Discharge Machining (EDM): Process parameters, mechanics, MRR, crater volume; EDM Surface Finishing: Machining accuracy, Surface hardness, electrode, dielectric fluid; Electron Beam Machining (EBM): Mechanics, power requirements

Unit 4: Laser and Plasma Arc Machining

Laser Beam Machining (LBM): Basics, types of lasers, mechanics of material removal, Heat conduction, cutting speed; Plasma Arc Machining: Overview and applications; Micro-Fabrication: Silicon/glass processes, soft lithograph

Unit 5: Advanced Finishing Processes

Abrasive Flow Finishing (AFF) and Magnetorheological Abrasive Flow Machining (MRAF): Basics, process parameters.

Recommended Books:

1. **V. K. Jain**, Advanced Machining Processes, Khanna Publishers, 2009.
2. **B. K. Parekh**, Non-Traditional Machining Processes, A. H. Wheeler & Co, 2007.
3. **Serope Kalpakjian and Steven R. Schmid**, Manufacturing Engineering and Technology, Pearson Education, 7th Edition, 2014.
4. **J. R. Davis,** Electrochemical Machining, ASM Handbook, Vol. 16, 1996.
5. **S. C. Mishra and R. K. Gupta,** Non-Conventional Machining Processes, Wiley, 2018.
6. **B. L. Juneja**, Advanced Machining Processes, New Age International, 2007.

Industrial Engineering Lab-I LTP (002)

Subject Code MME-1001P

List of experiments:

1. P-chart for fraction defectives
2. C- chart for number of defectives (constant sample size)
3. Operating characteristic curve of single sampling Attributes plan
4. Test for normality of sample means (normal distribution)
5. Test for normality of sample means (universal distribution Rectangular)
6. X, R – charts & process capability
7. Pin board study experiment

Subject Code MME-1013P
Subject Code MME-1009P

Simulation Lab/ Heat Transfer Lab

LTP (002)

List of Experiments of Simulation Lab:

1. Forecasting methods
2. Inventory management
3. MRR Modeling
4. Simulate analog and digital function blocks
5. PDCA cycle
6. 5S
7. Kaizen

List of Experiments of Heat Transfer Lab:

1. To determine temperature distribution and heat transfer in pool boiling conditions.
2. To determine temperature distribution of a solid slab
3. Analysis of fin using MATLAB.
4. To determine the heat transfer in film wise and drop wise condensation process.
5. To determine the emissivity of grey surface.
6. To study and analysis of compact heat exchanger.
7. To study of heat pipe.
8. To find thermal conductivity of powders/ liquids.

Semester II (Even Semester)

Subject Code MME-1016C **Metal Cutting Principles and Manufacturing Technology** **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Understand and analyze the different cutting zones (shear zone, friction zone, etc.) and their influence on cutting forces, tool life, and surface finish.
CO 2: Analyze and calculate the cutting forces involved in various machining operations and their impact on tool wear, machine tool capacity, and workpiece accuracy.
CO 3: Understand the mechanisms of tool wear (abrasion, adhesion, diffusion, and plastic deformation) and its effect on machining efficiency and product quality.
CO 4: Understand the environmental impacts of traditional and non-traditional machining processes, including energy consumption, waste generation, and emissions.

Unit 1: Tool Geometry and Metal Cutting Mechanics:

Tool Geometry: Reference planes, ASA, ORS, NRS systems, tool angles, twist drill, helical cutter; Metal Cutting Mechanics: Merchant's Circle, friction, stress, strain, shear angle, thin/thick zone models

Unit 2: Friction and Oblique Cutting:

Friction in Cutting: Sliding, sticking zones, Zorev’s model, mean friction angle; Oblique Cutting Mechanics: Rake angles, shear angles, velocity, force relationships

Unit 3: Machining and Cutting Forces:

Machining Operations: Turning, shaping, milling, drilling, MRR, power, time per pass; Cutting Force Measurement: Measurement methods, dynamometers

Unit 4: Tool Wear, Life, and Economics:

Tool Wear and Life: Wear types, mechanisms, tool life factors, machinability; Machining Economics: Cost, production rate, profit criteria, cutting restrictions

Unit 5: Thermal Aspects and Abrasive Machining:

Thermal Aspects: Heat regions, shear plane, chip-tool temperature; Abrasive Machining: Grinding types, wheel specs, mechanics, honing, lapping

Recommended Books:

1. **G. K. Lal and R. K. Gupta**, *Machining and Machine Tools*, New Age International, 3rd Edition, 2006.
2. **R. K. Jain**, *Introduction to Mechanical Machining*, Khanna Publishers, 2009.
3. **V. K. Jain**, *Advanced Machining Processes*, Khanna Publishers, 2009.
4. **D. K. Singh**, *Machining Technology: Machine Tools and Operations*, McGraw-Hill Education, 2013.

5. **Serope Kalpakjian and Steven R. Schmid**, *Manufacturing Engineering and Technology*, Pearson Education, 7th Edition, 2014.
6. **P. B. Bhattacharya**, *Abrasive Machining and Finishing*, Tata McGraw-Hill, 2006.

Subject Code MME-1018C | **Total Quality Management** | **LTP (310)**

Course Outcomes (COs)

At the end of the course, the student will be able to:

CO 1: Students will understand the core principles and philosophy of Total Quality Management (TQM), including customer focus, continuous improvement, employee involvement, and process approach.

CO 2: Learn to implement Plan-Do-Check-Act (PDCA) cycles to drive improvements in quality and operational efficiency within organizations.

CO 3: Develop skills to form and lead cross-functional teams in problem-solving, process improvement, and quality initiatives, fostering collaboration between departments such as marketing, production, and R&D.

CO 4: Understand various international quality standards and certifications, such as ISO 9001, ISO 14001, and Six Sigma certifications, and their role in ensuring consistent quality in global markets.

Unit 01: Introduction: Evolution of Quality: Quality Definition, Need for Quality, Dimensions of Product and Service Quality, Basic Concepts of TQM, TQM Framework, Quality Philosophies, Contributions of Deming, Juran and Crosby, Feiganbaum, Ishikawa and Taguchi, Barriers to TQM, Quality Statements, Customer Focus, Customer Orientation, Customer satisfaction, Customer Complaints, Customer Retention, Costs of Quality.

Unit 02: TQM Principles: Leadership: Strategic Quality Planning, Quality Councils, Employee Involvement, Motivation, Empowerment, Team and Teamwork, Quality Circles Recognition and Reward, Performance Appraisal, Continuous Process Improvement, PDCA Cycle, 5S, Kaizen, Supplier Partnership, Partnering, Supplier Selection, Supplier Rating.

Unit 03: Statistical Process Control: Statistical Fundamentals such as Mean and Standard Deviation, Chance and Assignable Causes, Control Charts for Variables, Process Capability Analysis such, Seven basic (Traditional) various Quality Control Tools: such as t) Pareto Chart (80-20 Rule), Control charts.

Unit 04: Quality Management Systems: Introduction, Benefits of ISO Registration, ISO 9000 Series of Standards, ISO 9001, Requirements, Implementation, Quality Auditing, TQM Culture, Quality Auditing, QS 9000, ISO 14000, Concepts, Requirements and Benefits, TQM Implementation in Manufacturing and Service Sectors.

Recommended Books:

1. **James R. Evans and William M. Lindsay**, The Management and Control of Quality, Cengage Learning, 8th Edition, 2016.
2. **Philip B. Crosby**, Quality is Free: The Art of Making Quality Certain, McGraw-Hill, 1979.
3. **S. K. Sharma**, Total Quality Management, S. Chand & Company, 2008.
4. **R. K. Gupta**, Total Quality Management: A Practical Approach, Wiley, 2012.
5. **S. M. J. Reza**, ISO 9000:2000 Quality Systems Handbook, Butterworth-Heinemann, 2001.
6. **David Hoyle**, ISO 9000 Quality Systems Handbook: Using the Standards as a Framework for Business Improvement, Butterworth-Heinemann, 5th Edition, 2017.

Subject Code MME-1020C **Operations Management** **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Gain a solid foundation in key operations management concepts such as process design, supply chain management, inventory control, quality management, forecasting, and capacity planning.
CO 2: Understand how operations fit into the overall strategy of an organization
CO 3: Understand how to design and manage efficient and effective production processes.
CO 4: Develop the ability to use forecasting techniques to predict demand and guide operational decision-making.
CO 5: Learn how to apply lean tools (e.g., Value Stream Mapping, Kaizen) and agile principles in operational settings.

Unit 1: Operations Strategy and Competitiveness

- Competitiveness in operations management
- Operations strategy development
- Balanced Scorecard
- Facility location and layout decisions
- Decision analysis techniques

Unit 2: Product and Service Management

- Product and service design
- Quality Function Deployment (QFD)
- Process planning and selection
- Quality control methods
- Inventory control principles

Unit 3: Lean Production

- Lean production systems
- Principles of Lean
- Lean Tools and Techniques
- Challenges in Lean Implementation

Unit 4: Project Management

- Project management fundamentals
- Work design and measurement
- Resource planning and scheduling

Unit 5: Forecasting and Sustainable Manufacturing

- Forecasting methods

- Inventory management
- Sustainable manufacturing practices
- Impact of sustainability on operations strategy

Recommended Books:

1. Russel, and Taylor, Operations management, Wiley India, 2011.
2. Krajewski, Ritzman, and Malhotra, Operations management, Pearson Prenctice Hall, 1993. Heizer, and Render, Operations management, Pearson Education, 2010.
3. Stevenson, Operations Management, McGraw Hill, 1982.
4. Chase and Aquilano, Operations Management, Tata McGraw Hill, 2006

Subject Code MME-1022C | **Robotics and Automation** | **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Learn how to integrate sensors into robotic systems for sensor fusion to enhance robot perception, localization, and environmental interaction.
CO 2: Students will be able to analyze and solve problems related to robot kinematics, including forward kinematics, inverse kinematics, and motion planning for both serial and parallel robots.
CO 3: Understand advanced control techniques such as PID control, adaptive control, and model-based control to improve the accuracy, efficiency, and robustness of robot systems.
CO 4: Learn about SLAM (Simultaneous Localization and Mapping), navigation, and motion planning algorithms for autonomous mobile robots and drones.

Unit 1: Introduction to Robotics and Sensors:
Introduction to robots; Internal and external sensors; Overview of actuators, including hydraulic, pneumatic, and electric actuators; Fundamentals of robot programming.

Unit 2: Kinematics and Dynamics of Manipulators:
Homogeneous transformations; D-H parameter notation; Direct and inverse kinematics of manipulators; Examples of kinematics of common manipulator configurations; Jacobian matrix.

Unit 3: Trajectory Planning and Automation:
Trajectory planning for robotic movement; Overview of automation; Types of automation, including fixed, programmable, and flexible automation.

Unit 4: Automated Systems Analysis:
Analysis of automated assembly systems; Line balancing problems in automation; Analysis of automated material handling systems; Automated storage and retrieval systems.

Recommended Books:

1. **R. K. Mittal and I. J. Nagrath**, *Robotics and Control*, Tata McGraw-Hill, 2nd Edition, 2003.
2. **K.S. Fu, R.C. Gonzalez, C.S.G. Lee**, *Robotics: Control, Sensing, Vision, and Intelligence*, McGraw-Hill, 1987.
3. **S. K. Gupta**, *Introduction to Robotics and Automation*, Tata McGraw-Hill, 2007.
4. **John J. Craig**, *Introduction to Robotics: Mechanics and Control*, Pearson, 3rd Edition, 2009.

Subject Code MME-1030P **Industrial Engineering Lab-II** **LTP (002)**

<u>List of Experiments of Industrial Engineering Lab:</u>

1. To study & Prepare Man-Machine Chart for the given situation.
2. To study & Prepare a frequency Distribution Curve for the data source given.
3. Z-test, t-test, chi-square tests, Mann-Whitney U test, f test, ANOVA
4. Regression analysis
5. Taguchi analysis
6. Time series forecasting
7. Draw the normal distribution curve, calculate Deviation, Variance, Range and determine the process capability.

Recommended Books:

Subject Code MME-1026P **Computer Aided Manufacturing Lab** **LTP (002)**

<u>List of Experiments of Computer Aided Manufacturing Lab:</u>

1. Exercises on part Modelling (Using different software)
2. Exercises on assembly Modelling
3. Generation of CNC codes from a CAD models
4. Demonstration/use of various CNC Machines

References Books:

1. D. F. Rogers and J. A. Adams, Mathematical Elements of Computer Graphics, 15th Reprint.
2. McGraw Hill International, 2008.
3. Zeid, CAD/CAM: Theory and Practice, 2nd ed. Tata McGraw Hill, 2009.
4. N. D. Bhatt and V. M. Panchal, Machine Drawing, 53rd ed. Charotar Publishing House, 2014.
5. E. P. Popov, Engineering Mechanics of Solids, 2nd ed. Prentice Hall of India, 2000.
6. Butterworth-Heinemann, 2017.
7. O. C. Zienkiewicz, R. L. Taylor, and J. Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, 7th ed. Butterworth-Heinemann, 2013.

Subject Code MME-1024E | **Operation Research Elective-II** | **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Students will learn to formulate real-world problems as mathematical models, such as linear programming, integer programming, network models, and other optimization techniques.
CO 2: Students will be able to apply optimization techniques, such as linear programming, dynamic programming, and simulation.
CO 3: Students will understand the applications of Operations Research across different fields, including business, engineering, healthcare, and public sector planning.

Unit 1: Introduction to Operations Research:

- Overview of operations research and its historical development
- Introduction to mathematical programming models
- Overview of computational techniques in operations research

Unit 2: Linear Programming and Sensitivity Analysis:

- Linear programming fundamentals and the simplex method
- Sensitivity analysis and its applications
- Transportation problem and its solution methods

Unit 3: Advanced Programming Techniques:

- Dynamic programming and its applications
- Integer programming and goal programming concepts
- Network analysis and optimization techniques

Unit 4: Stochastic Models in Operations Research:

- Introduction to stochastic models in engineering applications
- Poisson processes and their relevance
- Birth and death processes in queuing models
- Inventory models and their applications in operations research

Recommended Books:

1. **Hillier, F.S., & Lieberman, G.J.**, *Introduction to Operations Research*, McGraw-Hill, 10th Edition, 2015.
2. **Winston, W. L.**, *Operations Research: Applications and Algorithms*, Cengage Learning, 4th Edition, 2003.
3. **Chakravarty, S. R.**, *Mathematical Programming: Theory and Methods*, Tata McGraw-Hill, 1987.
4. **K. B. S. Murthy**, *Inventory Control and Management*, Springer, 2002.

Subject Code MME-1026E | **Computer Aided Design and Manufacturing Elective-II** | **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Students will understand the principles, tools, and techniques of computer-aided design and computer-aided manufacturing, including their applications and impact on modern manufacturing.
CO 2: Students will develop skills to create complex 3D models, assemblies, and technical drawings, applying design rules, constraints, and standards for manufacturability.
CO 3: Students will understand CNC machining principles, setup, and operations, including programming basics, machining parameters, and optimization techniques for automated manufacturing.
CO 4: Students will collaborate on design and manufacturing projects, effectively communicating technical ideas and solutions, and presenting their work to peers and stakeholders.

Unit 1: Introduction to CAD/CAM/CIM:

Introduction to CAD: Overview, role in design and manufacturing, Computer Aided Process Planning (CAPP): Concepts, need, benefits, Computer Aided Manufacturing (CAM): Automation and integration, Computer Integrated Manufacturing (CIM): Concept, components, Product Cycle and Automation: Role of automation in CAD/CAM.

Unit 2: Process Planning and CAPP:

Process Planning: Basic concepts, importance in manufacturing, CAPP: Introduction to Retrieval/Variant and Generative approaches, CAPP Implementation: Key considerations and challenges.

Unit 3: Numerical Control of Machine Tools:

Numerical Control (NC): Principles and advantages, Computer Numerical Control (CNC): Basics, types, and comparison with NC, Direct Numerical Control (DNC): Overview and applications, CNC System Classification: NC coordinate systems, positional control, System Devices: Drives, ball screws, transducers, feedback and counting devices.

Unit 4: NC Part Programming:

Part Programming: Concept and format of NC programs, Codes and Commands: Preparatory codes, miscellaneous codes, Manual Programming: Basics and examples, APT Programming: Introduction to Automatic Programming Tool, Macros and Fixed Cycles: Use and application in NC programming.

Unit 5: Group Technology, CIM, and FMS:

Group Technology (GT): Needs, part families, and coding systems, GT Machine Cells: Benefits and implementation in manufacturing, CIM Components: Hierarchical computer systems, transfer lines, Flexible Manufacturing System (FMS): Introduction, benefits, and tool management, Workpiece Handling Systems: Key aspects of automation in FMS

Recommended Books:

1. **Radhakrishnan, P., & Subramanyan, S.**, *CAD/CAM: Principles and Applications*, New Age International, 3rd Edition, 2008.
2. **M. P. Groover**, *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson Education, 4th Edition, 2014.
3. **R. K. Jain**, *Numerical Control and Computer-Aided Manufacturing*, McGraw-Hill, 2010.
4. **S. S. Rao**, *Flexible Manufacturing Systems*, Wiley, 2nd Edition, 2012.

Subject Code MME-1028E | **Additive Manufacturing Elective-II** | **LTP (310)**

Course Outcomes (COs)
At the end of the course, the student will be able to:

CO 1: Students will gain a solid foundation in the principles and history of additive manufacturing (AM), including its key technologies, materials, and processes.
CO 2: Students will use CAD software to design 3D models for AM, preparing digital files (e.g., STL) for 3D printing and understanding the requirements for effective digital fabrication.
CO 3: Students will gain knowledge of materials used in AM, including polymers, metals, and composites, and learn how to select and optimize materials based on the desired properties of the final product.
CO 4: Students will understand the diverse applications of AM across industries like aerospace, healthcare, automotive, and consumer products, recognizing AM's impact on product development, customization, and supply chain management.

Unit 1: Principles of Additive Manufacturing:
- Introduction to additive manufacturing (AM) and its definitions (ISO/ASTM)
- Generic AM process steps and characteristics
- Comparison of AM and conventional manufacturing processes
- Classification methods for AM technologies and production economics

Unit 2: AM Materials and Characterisation:
Nature of Thermoplastics and Thermosetting Polymers, Properties of Metal and Ceramics; AM Liquid Materials: Rheology and Wetting Behaviour; AM Solid Materials: Filament Diameter Consistency, Density, Porosity, Moisture Content, Thermal Properties, Microstructure of Composite Filament, Mechanical Properties of Filament; AM Powder Materials: Powder Size Measurements, Morphology, Chemical Composition, Flow Characteristics, Density, Energy Absorption Characteristics of Powder;

Unit 2: 3-D Data Files and Digital Workflow:
- Overview of 3-D data digital forms and formats
- Scanning, digitization, and CAD generation for AM
- Functions of AM software and digital workflow
- Tessellation, chordal error, and slicing algorithms
- STL format limitations and file editing

Unit 3: Additive Manufacturing Processes-I:
- Material extrusion (MEX) and related technologies
- Powder bed fusion (PBF) processes and variants
- Process parameters, energy correlations, and analytical modeling
- Directed energy deposition (DED) and its characteristics
- Post-processing techniques and evaluation of mechanical properties

Unit 4: Additive Manufacturing Processes-II:
- Vat photopolymerization (VPP) technologies and reaction mechanisms

- Binder jetting (BJ) processes and printability considerations
- Material jetting (MJ) and cold spray AM techniques
- Hybrid additive manufacturing and simulation of AM processes
- Emerging technologies in AM

Unit 5: Design Aspects and Applications of Additive Manufacturing:

- Applications in medical modeling, automotive, aerospace, and architecture
- Testing and certification of AM parts per ASTM/ISO standards
- Guidelines for AM process selection and design for AM
- Topology optimization and generative design concepts

Recommended Books:

1. **I. Gibson, D. W. Rosen, B. Stucker**, *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*, Springer, 2nd Edition, 2015.
2. **T. B. Hoos, S. M. M. M. Chen**, *Data Management and Digital Fabrication for 3D Printing*, Springer, 2018.
3. **G. H. Brunner**, *Digital 3D Printing: Processes, Materials, and Applications*, Wiley, 2018. **R. J. K. M. B. B. L. Wang**, *Advanced Materials and Techniques for Additive Manufacturing*, Wiley, 2020.
4. **L. M. S. K. Balasubramanian**, *Additive Manufacturing Technologies: An Overview of 3D Printing, Photopolymerization, and Other Methods*, Wiley, 2020.