VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

(VJTI)

MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to the University of Mumbai)

Curriculum

(Scheme of Instruction & Evaluation and Course contents)

For

Fourth Year

of

Four Year Undergraduate Programme Leading to

Bachelor of Technology (B. Tech.) Degree in Production Engineering

Implemented from the batch admitted in first year, 2023-24

Vision and Mission of the Institute

Vision

To establish global leadership in the field of Technology and develop competent human resources for providing service to society.

Mission

- To provide students with comprehensive knowledge of principles of engineering with a multi-disciplinary approach that is challenging
- To create an intellectually stimulating environment for research, scholarship, creativity, innovation, and professional activity.
- To foster relationships with other leading institutes of learning and research, alumni and industries to contribute to National and International development.

Vision and Mission of the Department

Vision

To develop technically competent and disciplined production engineers with creativity, comprehension and managerial skills to serve as a preferred provider of Manufacturing and Industrial Engineering students and services that satisfy the changing needs of all customer segments.

Mission

- Inculcate and develop the students who will be able to design and manufacture innovative, environmentally friendly, ergonomic and cost-effective quality products and services.
- Enhance the technical quality of the students to fulfil the challenges, competitions and opportunities in Production/ Industrial Engineering.
- Prepare the students to solve community-related engineering problems and other complex problems by means of inculcating technical managerial skills.
- Strive continuously to pursue excellence in all the areas of Manufacturing/ Industrial and enhance the department-industry/research centre interaction by means of training, internship and student projects to solve industrial problems.

Program Educational Objectives (PEO)

- To prepare the Graduates with a sound foundation in the mathematical, scientific and engineering fundamentals and equip them with modern tools so as to analyze, formulate, and solve real-life manufacturing and industrial engineering problems.
- To prepare graduates to become product and process design professionals for sustainable manufacturing.
- To prepare the graduates for a successful career in Indian and Multinational organizations and to excel in their Postgraduate studies.
- To encourage and motivate graduates in the art of self-learning.
- To inculcate a professional and ethical attitude, good leadership qualities, and commitment to social responsibilities in the graduates' thought process.

Program Outcomes (PO)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSO):

- Identify, formulate, and analyze complex engineering problems to solve real-life problems in the areas of mechanical design, tool design, advanced manufacturing methods, quality assurance, and industrial Engineering.
- Graduates would provide middle-level managerial leadership-based study and practice of industrial management imparted during the program while working in design and manufacturing industries.
- To employ modern industrial engineering/ management techniques to improve the value of the product by improving the quality and reducing the cost of manufacturing.

Credit Framework for UG Programme in Production Engineering

(Level 6.0 – B.Tech.) – Semester – VII

S. No	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
								TA	MST	ESE
1	R5PE4001T	Operations Research	3	0	0	3	3	20	30	50
2	R5PE4001L	Operations Research Laboratory	0	0	2	2	1	ISCE: 60		40
3	R5PE41xxT	Program Elective – 3	3	1	0	4	4	20	30	50
4	R5PE41xxT	Program Elective – 4	3	1	0	4	4	20	30	50
5	*	Multi-disciplinary Minor – V	3	1	0	4	4	20	30	50
6	#	Open Elective – 2	3	1	0	4	4	20	30	50
7	R5PE4801P	Project	0	0	8	8	4	ISCE: 60		40
		Total	**15**	**4**	**10**	**29**	**24**			

Abbreviations:

L: Lecture, **T**: Tutorial, **P**: Practical, **Cr:** Credit **TA**: Teacher Assessment, **MST**: Mid-Semester Test, **ESE**: End Semester Examination, **ISCE:** In Sem Continuous Evaluation

***:** course code of respective Multi-Disciplinary Minor (MDM) course

#: course code of respective Open Elective – 2 course

Program Elective – 3 (PEC 3) (Sem VII)	
Course Code	**Course Title**
R5PE4101T	Business Analytics
R5PE4102T	Circular Manufacturing and Circular Economy
R5PE4103T	Applications of AI and ML in Manufacturing
R5PE4104T	Composite Materials Processing Technology

Program Elective – 4 (PEC 4) (Sem VII)	
Course Code	**Course Title**
R5PE4105T	Sales and Marketing
R5PE4106T	Tribology in Manufacturing
R5PE4107T	Logistics Management
R5PE4108T	Industrial Robotics

Credit Framework for UG Programme in Production Engineering

(Level 6.0 – B.Tech.) – Semester – VIII

S. No	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
								TA	MST	ESE
1	R5PE4701I	Internship	–	12				ISCE: 60		40
2		Research Methodology (Online)	2	0	0	2	2	ISCE: 60		40
		Total	**2**	**0**	**0**	**2**	**14**			

Semester VII

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4001T	
Course Title	Operations Research	
Prerequisites	Applied Probability and Statistics	

Course outcomes:

On the completion of this course, the learner will be able to

1. Formulate and model real-life industrial and managerial problems using Operations Research techniques.
2. Apply optimization methods and mathematical tools to obtain optimal solutions for decision-making problems.
3. Analyze transportation, assignment, queuing, network, and game theory models for engineering applications.
4. Utilize software tools such as LINGO, Excel, WINQSB, QM, and TORA for solving Operations Research problems.
5. Evaluate and interpret optimization results for effective decision-making in industrial and management systems.

Syllabus

1. Modelling and Linear Programming Problems (LPP)

Introduction to Operations Research, scope, applications, modeling approach, and limitations. Formulation of Linear Programming Problems and solution techniques using graphical method, Simplex method, Big-M method, and Two-Phase method. Principle of duality, dual simplex method, and sensitivity analysis. Transportation and transshipment problems including formulation, initial feasible solution, optimal solution, and degeneracy. Assignment problems, optimal allocation, and Traveling Salesman Problem.

2. Integer and Dynamic Programming

Introduction to integer programming techniques including Gomory's cutting plane method, Branch and Bound Algorithm, and zero-one programming. Dynamic programming concepts, Bellman's Principle of Optimality, and applications to multistage decision-making problems such as capital budgeting and resource allocation.

3. Queuing / Waiting Line Theory

Introduction to queuing systems and their characteristics. Structure and behavior of waiting line models. Analysis of M/M/1 and M/M/C queuing models, steady-state conditions, system performance measures, and applications in industrial and service systems.

4. Game Theory

Introduction to game theory and competitive decision-making. Formulation of two-person zero-sum games, minimax and maximin principles, saddle point solutions, mixed strategies, dominance principle, solution of 2×2, m×2, and 2×n games, and graphical methods for game analysis.

5. Network Analysis and Project Management

Network terminology and formulation of network models. Algorithms for shortest path problems, maximum flow problems, and minimum spanning tree problems. Program Evaluation and Review Technique (PERT), Critical Path Method (CPM), network updating, project crashing, and resource leveling techniques.

6. Replacement Models

Introduction to replacement analysis. Replacement of deteriorating items under conditions where time value of money is considered and not considered. Replacement policies for items that fail completely and group replacement strategies.

7. Engineering Optimization and Multi-Criteria Decision Making (MCDM)

Introduction to optimization techniques including single-variable and multivariable optimization methods, constrained optimization methods, and advanced optimization techniques such as Genetic Algorithms, Simulated Annealing, and Particle Swarm Optimization. Fundamentals of Multi-Criteria Decision Making including Analytical Hierarchy Process (AHP), Weighted Product Method, Analytical Network Process (ANP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

8. Simulation

Introduction to simulation, types of simulation models, phases of simulation, and Monte Carlo simulation techniques. Applications of simulation in inventory systems, production systems, and queuing problems along with advantages and limitations of simulation techniques.

Textbooks

1. J. K. Sharma – *Operations Research*, McMillan Publishing.
2. Hillier, Lieberman, Nag, and Basu – *Introduction to Operations Research*, McGraw Hill.

Reference Books

1. Winston Wayne – *Operations Research*, Cengage Learning.
2. Hamdy Taha – *Operations Research*, Pearson Education.
3. Ravindran and Phillips – *Operations Research: Principles and Practices*, Wiley India.
4. N. D. Vohra – *Quantitative Techniques in Management*, Tata McGraw Hill.

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4001L	
Course Title	Operations Research Laboratory	
Prerequisites	Applied Probability and Statistics	

Course outcomes:

On the completion of this course, the learner will be able to

1. Formulate and solve linear programming and other optimization problems using appropriate Operations Research techniques.
2. Apply transportation, assignment, network, and project optimization models to industrial and managerial decision-making problems.
3. Utilize optimization and simulation software tools such as TORA, Excel Solver, MATLAB, LINDO, and LINGO for modeling and analysis of complex systems.
4. Analyze and solve real-world industrial problems involving resource allocation, decision-making, and multi-criteria decision-making (MCDM) approaches.

Syllabus

The laboratory course focuses on the application of optimization, probability, and simulation techniques for modeling, analysis, and decision-making in complex industrial systems. Students shall perform experiments using software tools such as TORA, Excel Solver, MATLAB, LINDO, LINGO, and other relevant simulation software.

List of Experiments

1. Linear Programming Problems (LPP)

- Formulation of Linear Programming Problems from industrial scenarios
- Graphical and software-based solution techniques
- Solving at least six different types of LPPs using Excel Solver/TORA/LINDO/LINGO

2. Transportation and Transshipment Problems

- Formulation of transportation models
- Determination of optimal shipping schedules minimizing transportation cost

- Solving balanced and unbalanced transportation problems
- Transshipment problem modeling and optimization

3. Assignment Problems

- Formulation of assignment models
- Optimal allocation of persons, machines, or jobs to tasks
- Cost minimization and profit maximization problems

4. Network Optimization Problems

a) Shortest Path Problem

- Determination of shortest path in an undirected network
- Applications in routing and logistics systems

b) Maximum Flow Problem

- Determination of maximum flow in directed networks
- Applications in transportation and supply chain systems

5. Capital Budgeting and Investment Problems

- Formulation of capital investment models
- Selection of optimal investment combinations for maximum profit or return

6. Multi-Criteria Decision Making (MCDM)

- Introduction to MCDM techniques
- Solving industrial decision-making problems involving multiple criteria
- Applications in selection, ranking, and evaluation problems

7. Industrial Problem Solving Using OR Tools

- Modeling and analysis of real-life industrial and managerial problems
- Application of optimization and simulation techniques for decision-making
- Interpretation and presentation of software-generated results

Textbooks

1. J. K. Sharma – *Operations Research*, McMillan Publishing.
2. Hillier, Lieberman, Nag, and Basu – *Introduction to Operations Research*, McGraw Hill.

Reference Books

1. Winston Wayne – *Operations Research*, Cengage Learning.
2. Hamdy Taha – *Operations Research*, Pearson Education.
3. Ravindran and Phillips – *Operations Research: Principles and Practices*, Wiley India.
4. N. D. Vohra – *Quantitative Techniques in Management*, Tata McGraw Hill.

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4101T	
Course Title	Business Analytics	
Prerequisites	Applied Probability and Statistics, Industrial Engineering	

Course outcomes:

On the completion of this course, the learner will be able to

1. Understand the fundamentals, scope, and applications of business analytics in managerial decision-making.
2. Apply statistical and predictive modeling techniques for analysis and interpretation of business data.
3. Utilize optimization, simulation, and decision modeling techniques to solve business and industrial problems.
4. Analyze large datasets using data mining, warehousing, and analytical tools for business intelligence applications.
5. Use modern business analytics software and technologies for data-driven decision-making and organizational performance improvement.

Syllabus

1. Overview of Business Analytics

Introduction to business analytics, its evolution, scope, and significance in modern organizations. Role and responsibilities of business analysts, competencies required for effective business analysis, holistic approach to business analysis, and introduction to data visualization techniques for managerial decision-making.

2. Predictive Modeling

Concepts of predictive analytics and classification techniques. Decision trees as classification tools, regression models including linear and logistic regression, cluster analysis, segmentation techniques, and market basket analysis for identifying patterns and relationships in business data.

3. Statistics for Analytics

Role of statistics in business analytics involving qualitative and quantitative data analysis. Descriptive and inferential statistics, multivariate data analytics, correlation and regression analysis, hypothesis testing concepts, and use of software tools such as SPSS for data analysis and interpretation.

4. Decision Modeling and Business Optimization

Introduction to decision modeling and optimization techniques for solving business problems related to marketing mix, capital budgeting, and portfolio optimization. Simulation techniques for decision-making under uncertainty, applications in inventory management, investment analysis, market share estimation, and sensitivity analysis. Introduction to heuristic and meta-heuristic techniques, Multi-Criteria Decision-Making (MCDM), Group Decision Support Systems (GDSS), and analytics applications in Supply Chain Management.

5. Data Mining and Warehousing

Introduction to data mining concepts, data warehousing, and OLAP techniques. Data mining processes, methodologies, and tools such as XL Miner. Classification and Regression Trees (CART), along with applications and case studies related to market basket analysis, web analytics, social media analytics, and e-commerce analytics.

6. Advances in Business Analytics

Overview of Big Data technologies, Internet of Things (IoT), and Cloud Computing concepts. Introduction to modern analytics software and platforms such as Hadoop, R, Weka, SAS Enterprise Miner, IBM Watson, and Tableau for business intelligence and advanced analytical applications.

Textbooks

1. Debra Paul & Donald Yeates – *Business Analysis*, BCS Learning & Development Ltd.
2. Shmueli, Patel, and Bruce – *Data Mining for Business Intelligence: Concepts, Techniques, and Applications*, Wiley Publications.
3. Shmueli, Bruce, Stephens, and Patel – *Data Mining for Business Analytics: Concepts, Techniques, and Applications*, Wiley Publications.

4. Jay Liebowitz – *Business Analytics: An Introduction*, CRC Press.
5. Evans, J. R. – *Business Analytics: Methods, Models, and Decisions*, Pearson Education.

Reference Books

1. Albright, S. C., and Winston, W. L. – *Business Analytics: Data Analysis and Decision Making*, Cengage Learning.
2. James, G., Witten, D., Hastie, T., and Tibshirani, R. – *An Introduction to Statistical Learning*, Springer.
3. Han, J., Kamber, M., and Pei, J. – *Data Mining: Concepts and Techniques*, Morgan Kaufmann Publishers.
4. Davenport, T. H., and Harris, J. G. – *Competing on Analytics: The New Science of Winning*, Harvard Business Review Press.
5. Provost, F., and Fawcett, T. – *Data Science for Business*, O'Reilly Media.
6. Montgomery, D. C., and Runger, G. C. – *Applied Statistics and Probability for Engineers*, Wiley Publications.

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4102T	
Course Title	Circular Manufacturing and Circular Economy	
Prerequisites	Industrial Engineering, Supply Chain Management	

Course outcomes:

On the completion of this course, the learner will be able to

1. Understand the principles and concepts of circular economy and sustainable manufacturing systems.
2. Apply sustainable product design strategies including reuse, remanufacturing, and recycling approaches.
3. Analyze circular supply chains, waste reduction techniques, and resource recovery methods in manufacturing industries.
4. Utilize tools such as Life Cycle Assessment (LCA) and material flow analysis for sustainability evaluation.
5. Evaluate industrial practices, case studies, policies, and standards related to circular manufacturing and sustainability.

Syllabus

1. Introduction to Circular Manufacturing and Circular Economy

Introduction to sustainability and circular manufacturing concepts. Comparison between linear and circular economic models, principles of circular economy, resource efficiency, industrial sustainability, and circular business models for sustainable production systems.

2. Sustainable Product Design

Concepts of sustainable product development and eco-design. Design for disassembly, reuse, remanufacturing, and recycling. Product life extension strategies, environmentally conscious design principles, and sustainable material selection for circular manufacturing systems.

3. Circular Supply Chains

Introduction to circular supply chain management, reverse logistics, remanufacturing systems, and closed-loop manufacturing. Resource recovery, waste minimization, product take-back systems, and sustainable supply chain practices in industrial applications.

4. Tools and Methodologies for Sustainability Assessment

Introduction to Life Cycle Assessment (LCA), stages of LCA, environmental impact assessment, and sustainability evaluation techniques. Material flow analysis, resource utilization assessment, carbon footprint analysis, and tools for measuring sustainability performance in manufacturing systems.

5. Case Studies and Industrial Applications

Applications of circular manufacturing concepts in industries such as automotive, electronics, packaging, and consumer products. Industrial case studies related to circularity, sustainability practices, waste reduction, recycling systems, and environmental policies and standards supporting sustainable manufacturing.

Textbooks

1. Webster, K. – *The Circular Economy: A Wealth of Flows*, Ellen MacArthur Foundation.
2. Lacy, P., & Rutqvist, J. – *Waste to Wealth: The Circular Economy Advantage*, Palgrave Macmillan.
3. Stahel, W. R. – *The Circular Economy: A User's Guide*, Routledge.

Reference Books

1. Kirchherr, J., & Reike, D. – *Research on the Circular Economy: A Systematic Literature Review*, Elsevier.
2. Sharma, S. – *Circular Economy in Manufacturing: Practices and Challenges*, Springer.
3. Murray, A., Skene, K., & Haynes, K. – *The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context*, Journal of Business Ethics.
4. Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. – *The Circular Economy – A New Sustainability Paradigm?*, Journal of Cleaner Production.

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4103T	
Course Title	Applications of AI and ML in Manufacturing	
Prerequisites	CAD/CAM/CIM, Mechatronics and Automation	

Course outcomes:

On the completion of this course, the learner will be able to

1. Understand the fundamentals of Artificial Intelligence (AI) and Machine Learning (ML) in manufacturing applications.
2. Apply AI and ML techniques for process optimization, quality improvement, and predictive decision-making in manufacturing systems.
3. Analyze manufacturing data using machine learning algorithms and data-driven approaches.
4. Utilize AI-enabled tools and intelligent systems for automation, predictive maintenance, and smart manufacturing applications.
5. Evaluate industrial applications and case studies related to AI, ML, and Industry 4.0 technologies in manufacturing environments.

Syllabus

1. Introduction to Artificial Intelligence and Machine Learning

Introduction to Artificial Intelligence and Machine Learning concepts, scope, and applications in manufacturing industries. Overview of intelligent manufacturing systems, Industry 4.0, smart factories, digital transformation, and data-driven manufacturing. Types of AI and ML techniques, supervised, unsupervised, and reinforcement learning approaches.

2. Data Analytics and Machine Learning Techniques

Introduction to manufacturing data, data preprocessing, feature extraction, and data visualization techniques. Fundamentals of regression, classification, clustering, and neural networks. Machine learning algorithms such as Decision Trees, Support Vector Machines (SVM), K-Nearest Neighbors (KNN), and Artificial Neural Networks (ANN) for manufacturing applications.

3. AI and ML Applications in Manufacturing

Applications of AI and ML in process optimization, production planning, scheduling, quality control, defect detection, and supply chain management. Intelligent process monitoring, predictive analytics, demand forecasting, and real-time decision-making in manufacturing systems.

4. Predictive Maintenance and Smart Manufacturing

Concepts of predictive maintenance, condition monitoring, fault diagnosis, and reliability prediction using AI techniques. Internet of Things (IoT), Cyber-Physical Systems (CPS), digital twins, robotics, and automation in smart manufacturing environments. Integration of AI with Industrial IoT for intelligent manufacturing systems.

5. Industrial Applications and Case Studies

Industrial case studies related to AI and ML implementation in automotive, aerospace, electronics, additive manufacturing, and process industries. Challenges, ethical considerations, data security, sustainability aspects, and future trends in AI-enabled manufacturing systems.

Textbooks

1. Mikell P. Groover – *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson Education.
2. Stuart Russell & Peter Norvig – *Artificial Intelligence: A Modern Approach*, Pearson Education.
3. Ethem Alpaydin – *Introduction to Machine Learning*, MIT Press.

Reference Books

1. Kevin P. Murphy – *Machine Learning: A Probabilistic Perspective*, MIT Press.
2. Trevor Hastie, Robert Tibshirani, and Jerome Friedman – *The Elements of Statistical Learning*, Springer.
3. Ian Goodfellow, Yoshua Bengio, and Aaron Courville – *Deep Learning*, MIT Press.
4. Jay Lee – *Industrial AI: Applications with Sustainable Performance*, Springer.

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4104T	
Course Title	Composite Materials Processing Technology	
Prerequisites	Engineering Physics, Basic Manufacturing Technology	

Course outcomes:

On the completion of this course, the learner will be able to

1. Understand the fundamentals, classification, properties, and manufacturing processes of composite materials.
2. Analyze the strengthening mechanisms, fiber-matrix interactions, and engineering behavior of composite systems.
3. Apply suitable composite processing techniques for polymer, metal, ceramic, and nanocomposite materials.
4. Evaluate mechanical performance, testing methods, joining techniques, and failure mechanisms of composites.
5. Design and select composite materials for structural, industrial, and advanced engineering applications considering economic and environmental aspects.

Syllabus

1. Introduction to Composite Materials

Definitions and classification of composite materials. Types of reinforcements and matrices, properties of fiber-reinforced composites, comparison with conventional engineering materials, applications, quality assurance, economic aspects, and manufacturing defects. Concepts of fiber strengthening, critical fiber length, critical volume fraction, and natural composites such as wood and bone.

2. Fibers and Reinforcements

Manufacturing methods, physical, chemical, and mechanical properties of commonly used fibers including carbon, glass, aramid, ceramic, and organic fibers. Fiber coating techniques for compatibility with matrix materials, statistical characterization of fiber behavior, naturally occurring fibers, whiskers, and their manufacturing methods and applications.

3. Manufacturing of Polymer Matrix Composites

Principles of open and closed mould composite manufacturing processes including hand lay-up, spray lay-up, press molding, injection molding, resin injection molding, RRIM, filament winding, pultrusion, centrifugal casting, autoclave processing, and prepreg techniques. Machine methods for manufacturing composites, cutting, drilling, machining, and finishing operations.

4. Fiber-Matrix Interface

Theories of adhesion including absorption and wetting, inter-diffusion, electrostatic, chemical, and mechanical adhesion mechanisms. Measurement and characterization of interface strength in composite systems such as carbon fiber/epoxy and glass fiber/polyester composites. Influence of interface properties on composite mechanical behavior.

5. Matrix Systems in Composites

Polymer matrix systems including thermoplastic and thermosetting resins, curing reactions, mechanical properties, glass transition, and degradation behavior. Carbon fiber/epoxy, carbon fiber/PEEK, glass fiber/polyester, and short fiber reinforced polymer systems. Glass and ceramic matrix systems including hot pressing, sintering, vapor phase transport, and mechanical and electrical properties of ceramic composites. Introduction to metal matrix systems, solidification processes, diffusion bonding, and reinforced aluminium and titanium alloy composites.

6. Engineering Properties and Mechanical Testing

Geometrical aspects, volume fraction, weight fraction, and mechanics of unidirectional continuous fiber composites. Short fiber systems, woven reinforcements, hybrid composites, failure theories for lamina, and micromechanics theories. Mechanical testing methods for stiffness and strength evaluation under tension, compression, flexure, and shear. Strain measurement techniques including photoelastic and holographic methods.

7. Joining and Repair of Composites

Adhesively bonded and mechanically fastened joints, their advantages and limitations. Bonding procedures, joint strength evaluation, stress analysis, testing methods, and repair techniques for composite structures.

8. Design, Environmental Effects, and Nanocomposites

Design philosophy and procedures for composite structures including simple design studies, materials selection, and manufacturing considerations. Economic aspects and industrial case studies of composites. Environmental effects including moisture absorption, stress corrosion cracking, temperature effects, and long-term behavior prediction. Introduction to nanocomposites, nanomaterial properties, manufacturing methods, influence on mechanical properties, and engineering applications.

Textbooks

1. Ever J. Barbero – *Introduction to Composite Materials Design*, Taylor & Francis.
2. Robert M. Jones – *Mechanics of Composite Materials*, Taylor & Francis.

Reference Books

1. P. K. Mallick – *Fiber Reinforced Composite Materials: Manufacturing and Design*, CRC Press.
2. Robert M. Jones – *Mechanics of Composite Materials*, Taylor & Francis Group.
3. F. C. Campbell – *Manufacturing Processes for Advanced Composites*, Elsevier Ltd.
4. Venkatesan (Ed.) – *Composites and Processing Methods*, Narosa Publications.

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4105T	
Course Title	Sales and Marketing	
Prerequisites	Industrial Management, Managerial Economics, Finance and Costing	

Course outcomes:

On the completion of this course, the learner will be able to

1. Understand the fundamentals, concepts, and functions of sales and marketing management.
2. Apply marketing principles, tools, and techniques for business and industrial applications.
3. Analyze customer behavior, market opportunities, and competitive business environments for effective decision-making.
4. Evaluate product, pricing, promotion, and distribution strategies for organizational growth and customer satisfaction.
5. Develop managerial and entrepreneurial perspectives related to sales, marketing, customer relationship management, and business performance.

Syllabus

1. Introduction to Marketing Management

Definition, scope, and functions of marketing and sales management. Evolution from sales-oriented to marketing-oriented approaches, company orientations, marketing concepts, environmental forces affecting business, approaches to marketing, changing business practices, changing marketing practices, new economy, and introduction to e-business concepts.

2. Customer Value and Relationship Management

Concepts of customer value and customer satisfaction. Characteristics of consumer and organizational markets, attracting and retaining customers, cost of losing customers, customer relationship management (CRM), customer-focused strategies, and methods for survey and analysis of customer needs and expectations.

3. Marketing Opportunities and Product Management

Assessment of marketing opportunities, gathering market information, forecasting and demand measurement techniques. Organizational buying decision process, marketing decision support

systems, product life cycle concepts, portfolio management, new product development strategies, and buy-grid model.

4. Marketing Strategies and Marketing Mix

Competition analysis and market research techniques. Management strategies and marketing mix concepts including 4Ps of product marketing and 7Ps of service marketing. Product policies, branding strategies, service offerings, pricing methods, customer perceived value, distribution channels, retailing, marketing planning, and implementation strategies.

5. Sales Organization and Marketing Performance

Marketing organization structure, selection and training of marketing personnel, role and responsibilities of salespersons, routine sales management, salary and incentive systems, marketing intelligence systems, market response analysis, marketing performance evaluation, buyer behavior, negotiation capabilities, and customer satisfaction benchmarking.

6. Consumer Behaviour and Promotional Strategies

Concepts of consumer buying behavior and organizational buying behavior. Customer focus strategies, advertising, sales promotion techniques, motivation research, buying decision process, competitive strategies, audit of customer satisfaction, benchmarking practices, and evaluation of consumer society in modern business environments.

Textbooks

1. Philip T. Kotler, Gary Armstrong, and Prafulla Agnihotri – *Principles of Marketing*, Pearson Education.
2. V. Ramaswamy and S. Namakumari – *Marketing Management*, McGraw Hill Education.

Reference Books

1. J. Gandhi – *Marketing: A Managerial Introduction*, Tata McGraw Hill.
2. Mamoria C. B. and Joshi – *Marketing*, Kitab Mahal Publication.
3. R. Srinivasan – *Case Studies in Marketing: The Indian Context*, PHI Learning.
4. Belch & Belch – *Advertising and Promotion: An Integrated Marketing Communications Perspective*, McGraw Hill.

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4106T	
Course Title	Tribology in Manufacturing	
Prerequisites	Basic Manufacturing Technology, Engineering Materials and Applications	

Course outcomes:

On the completion of this course, the learner will be able to

1. Understand the fundamentals of tribology, friction, wear, and lubrication mechanisms in manufacturing systems.
2. Analyze surface interactions, wear behavior, and lubrication performance in engineering applications.
3. Apply tribological principles for improving machining, forming, and manufacturing process performance.
4. Evaluate lubrication systems, tribological materials, and surface engineering techniques for industrial applications.
5. Assess tribological failures and recommend suitable preventive measures for enhancing reliability and productivity in manufacturing systems.

Syllabus

1. Introduction to Tribology

Introduction to tribology and its importance in manufacturing industries. Fundamentals of friction, wear, and lubrication. Types of friction, mechanisms of friction, theories of friction, surface topography, surface roughness, and contact mechanics. Engineering significance of tribology in manufacturing and machine elements.

2. Wear and Surface Interaction

Mechanisms and types of wear including adhesive wear, abrasive wear, corrosive wear, erosive wear, fatigue wear, and fretting wear. Surface interaction phenomena, wear measurement techniques, wear resistance, and tribological behavior of engineering materials under different operating conditions.

3. Lubrication and Lubricants

Principles and functions of lubrication. Types of lubrication including hydrodynamic, boundary, mixed, and elastohydrodynamic lubrication. Properties and classification of lubricants, solid lubricants, additives, lubrication systems, selection of lubricants, and lubrication practices in manufacturing industries.

4. Tribology in Manufacturing Processes

Tribological aspects in machining, metal forming, rolling, forging, extrusion, drawing, and grinding processes. Friction and wear in cutting tools and dies, tool life improvement, lubrication in manufacturing operations, and tribological considerations in process optimization and productivity enhancement.

5. Surface Engineering and Tribological Materials

Surface modification and surface engineering techniques including coating, cladding, thermal spraying, nitriding, carburizing, and hardening processes. Tribological properties of metals, polymers, ceramics, and composite materials. Advanced tribological materials and nano-lubrication concepts.

6. Tribological Failure Analysis and Industrial Applications

Failure analysis of tribological components such as bearings, gears, seals, and machine elements. Condition monitoring, maintenance practices, reliability improvement, and case studies related to tribological failures in manufacturing systems. Industrial applications of tribology in automotive, aerospace, and heavy engineering sectors.

Textbooks

1. B. Bhushan – *Introduction to Tribology*, Wiley Publications.
2. Gwidon W. Stachowiak and Andrew W. Batchelor – *Engineering Tribology*, Butterworth-Heinemann.

Reference Books

1. Hutchings, I. M., and Shipway, P. – *Tribology: Friction and Wear of Engineering Materials*, Butterworth-Heinemann.
2. Sushil Kumar Srivastava – *Tribology in Industries*, S. Chand Publications.
3. Czichos, H. – *Tribology: A Systems Approach to the Science and Technology of Friction, Lubrication and Wear*, Elsevier.
4. Neale, M. J. – *Tribology Handbook*, Butterworth-Heinemann.

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4107T	
Course Title	Logistics Management	
Prerequisites	Industrial Engineering	

Course outcomes:

On the completion of this course, the learner will be able to

1. Understand the concepts, functions, and significance of logistics and supply chain systems in modern industries.
2. Analyze logistics operations including transportation, warehousing, inventory, and distribution systems.
3. Apply logistics planning, information systems, and outsourcing strategies for efficient logistics management.
4. Evaluate logistics performance, customer service, and global logistics practices for organizational effectiveness.
5. Develop managerial perspectives for improving logistics efficiency, sustainability, and supply chain competitiveness.

Syllabus

1. Fundamentals of Logistics

Introduction to logistics, objectives, scope, evolution of logistics, functions of logistics management, logistics and supply chain management, logistics mix, logistics as a competitive strategy, role of logistics in manufacturing and service industries, and applications of logistics in organized retail.

2. Integrated Logistics and Inventory Management

Concepts and objectives of integrated logistics. Procurement, manufacturing, and distribution logistics, inventory flow, information flow, customer service, inventory planning and control, order processing, logistics costs, logistics performance measurement, and key performance indicators (KPIs) in logistics management.

3. Warehousing and Distribution Management

Concepts and functions of warehousing, warehouse planning and design, warehouse operations, warehouse management systems (WMS), warehousing strategies, warehousing cost analysis, distribution centres, logistical packaging, packaging design considerations, protective packaging, palletization, unitization, and distribution planning.

4. Transportation Management

Transportation systems and infrastructure, modes of transportation, carrier selection, freight management, transportation costing, routing and scheduling, multimodal transportation, containerization, distribution network design, and last-mile delivery concepts.

5. Logistics Information Systems and Outsourcing

Concepts of Logistics Information Systems (LIS), Enterprise Resource Planning (ERP), Warehouse Management Systems (WMS), RFID, barcode systems, GPS, Internet of Things (IoT) applications in logistics, digital logistics, third-party logistics (3PL), fourth-party logistics (4PL), selection of logistics service providers, logistics contracts, and logistics performance evaluation.

6. Global Logistics and Emerging Trends

Global logistics and international supply chains, export-import logistics, customs procedures, reverse logistics, green logistics, sustainable logistics, humanitarian logistics, e-commerce logistics, risk management in logistics, resilient supply chains, and emerging trends in logistics and supply chain management.

Textbooks

1. Douglas Lambert and James Stock – *Strategic Logistics Management*.
2. Bowersox – *Logistical Management*, McGraw Hill Education.

Reference Books

1. Sahay, B. S. – *Supply Chain Management for Global Competitiveness*, Macmillan India Ltd.
2. Raghuram, G., and Rangaraj, N. – *Logistics and Supply Chain Management: Cases and Concepts*, Macmillan India Ltd.
3. John Coyle, Edward Bardi, and John Langley – *The Management of Business Logistics*, Thomson Learning.
4. Sunil Chopra and Peter Meindl – *Supply Chain Management: Strategy, Planning, and Operation*, Pearson Education.

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R5PE4108T	
Course Title	Industrial Robotics	
Prerequisites	CAD/CAM/CIM, Mechatronics and Automation	

Course outcomes:

On the completion of this course, the learner will be able to

1. Understand the fundamentals, components, classifications, and applications of industrial robots.
2. Analyze robot kinematics, dynamics, motion control, and programming techniques for industrial automation.
3. Apply robotic systems and end effectors in manufacturing, material handling, assembly, and inspection operations.
4. Evaluate sensors, vision systems, and control strategies used in robotic and automated manufacturing systems.
5. Assess industrial robotic applications, integration issues, and safety considerations in modern manufacturing environments.

Syllabus

1. Introduction to Industrial Robotics

Introduction to robotics, history and evolution of industrial robots, need and scope of robotics in manufacturing industries. Components of robotic systems, classifications of robots based on configuration and application, robot anatomy, work envelope, degrees of freedom, and applications of robots in industrial automation.

2. Robot Kinematics and Dynamics

Coordinate systems and transformations, robot joints and links, forward and inverse kinematics, robot motion analysis, trajectory planning, velocity and acceleration analysis, and basics of robot dynamics. Introduction to robotic manipulators and motion control systems.

3. Robot Drives, Actuators, and End Effectors

Types of robot drive systems including hydraulic, pneumatic, and electric drives. Actuators used in robotic systems, transmission systems, grippers, end effectors, and tooling for material handling, welding, assembly, machining, and inspection applications.

4. Sensors and Robot Vision Systems

Introduction to robotic sensors and sensing systems. Position, proximity, force, torque, tactile, and vision sensors. Machine vision systems, image processing concepts, object recognition, inspection systems, and sensor integration in robotic applications.

5. Robot Programming and Control

Methods of robot programming including lead-through programming, robot programming languages, offline programming, and simulation. Control systems for robots including point-to-point control, continuous path control, adaptive control, and intelligent robotic systems.

6. Industrial Applications and Robot Integration

Applications of industrial robots in material handling, welding, assembly, painting, inspection, packaging, and flexible manufacturing systems. Robot cell design, robot integration in manufacturing systems, economic considerations, safety standards, maintenance, and future trends in robotics and Industry 4.0.

Textbooks

1. Mikell P. Groover – *Industrial Robotics: Technology, Programming and Applications*, McGraw Hill Education.
2. S. R. Deb – *Robotics Technology and Flexible Automation*, Tata McGraw Hill.

Reference Books

1. Fu, Gonzalez, and Lee – *Robotics: Control, Sensing, Vision and Intelligence*, McGraw Hill.
2. Craig, J. J. – *Introduction to Robotics: Mechanics and Control*, Pearson Education.
3. Klafter, Chmielewski, and Negin – *Robotic Engineering: An Integrated Approach*, Prentice Hall.
4. Richard D. Klafter – *Robotic Engineering*, PHI Learning.

Semester VIII

Programme	B. Tech. (Production Engineering)	**Semester - VIII**
Course Code	R5PE4701I	
Course Title	Internship	

Course outcomes: On the completion of this course, the learner will able to

1. Understand the organizational structure, production systems, and operational practices of industrial organizations.
2. Analyze industrial processes, technological trends, and managerial practices relevant to Production Engineering.
3. Apply engineering knowledge and analytical skills to identify, investigate, and solve practical industrial problems.
4. Demonstrate understanding of application-oriented subjects through industrial training and project execution.
5. Evaluate industrial constraints related to productivity, quality, cost, time, safety, and resource utilization in manufacturing and service operations.

Syllabus

Course Approach

The course emphasizes practical exposure and hands-on experience to understand industrial practices and address real-life engineering problems.

The course includes:

- Industrial training and field exposure
- Investigative and analytical problem-solving approach
- Case studies and application-oriented assignments
- Integration of theoretical and practical knowledge
- Development of technical documentation and presentation skills

The project report shall include:

- Problem definition and objectives

- Background study and literature review
- Identification of possible approaches
- Methodology adopted
- Data collection and analysis
- Investigation/results obtained
- Conclusions and recommendations

Students are expected to prepare a factual and technically sound report emphasizing clarity, brevity, neatness, and systematic presentation.

Broad Areas of Training / Project Work

The following areas are indicative and not exhaustive. The project/training may involve one or more interdisciplinary areas related to Production Engineering:

1. Process Engineering and Process Planning
2. Design and Manufacturing of Production Tooling
3. Product and Process Innovation & Development
4. Production Planning and Production Management
5. Quality Control, SQC, SPC, TQM, and Rejection Analysis
6. Cost Reduction, Value Engineering, and Productivity Improvement
7. Plant Layout, Material Handling, and Method Study
8. Industrial Engineering and Operations Research Applications
9. Inventory Control, Stores, and Purchase Management
10. Maintenance Engineering and Plant Engineering
11. Process Optimization and Manufacturing Technology
12. Any industrial problem involving analysis, investigation, and application of Production Engineering principles in line with the VJTI curriculum.

Guidelines for Evaluation and Assessment

Evaluation of the industrial training and project work shall be based on the following aspects:

1. Technical content, depth of work, and practical relevance of the project/training undertaken.
2. Clarity, effectiveness, and professionalism in presentation and documentation.
3. Student involvement, initiative, contribution, and quality of work carried out.
4. Progress made in project execution and problem-solving approach adopted.
5. Company profile, organizational background, and details of training/work carried out.
6. Synopsis/abstract, introduction, acknowledgements, and references included in the report.
7. Technical analysis supported with relevant data, observations, graphs, drawings, and results.
8. Quality of investigation, analytical approach, and personal understanding demonstrated.
9. Conclusions, recommendations, and overall outcomes of the work carried out.

Programme	B. Tech. (Production Engineering)	**Semester - VIII**
Course Code		
Course Title	Research Methodology (Online)	

Course outcomes: Upon successful completion of this course, the learner will be able to:

1. Understand the fundamentals of research methodology, research processes, and problem identification.
2. Conduct literature review and apply ethical practices in technical research and academic writing.
3. Apply data collection, statistical analysis, and interpretation techniques for engineering research problems.
4. Develop technical writing, documentation, and presentation skills for effective research communication.
5. Understand the fundamentals of intellectual property rights, patents, innovation processes, and research commercialization.

Syllabus

1. Introduction to Research Methodology

- Meaning, objectives, and significance of research
- Characteristics and types of research
    - Fundamental and applied research
    - Qualitative and quantitative research
    - Experimental and analytical research
- Research process and identification of research problems
- Research objectives and hypothesis formulation
- Research design and methodology

2. Literature Review and Research Ethics

- Importance and sources of literature review

    - Books, journals, conference papers, patents, and online databases
- Literature survey and review techniques
- Citation and referencing styles
    - APA, IEEE, and other standard formats
- Reference management tools
    - Mendeley, Zotero, EndNote
- Research ethics and academic integrity
- Plagiarism: types, consequences, and plagiarism detection tools

3. Data Collection and Analysis Techniques

- Methods of data collection
    - Primary and secondary data
    - Surveys, questionnaires, interviews, and experiments
- Sampling techniques and questionnaire design
- Introduction to statistical analysis
    - Descriptive statistics
    - Correlation and regression
    - Basics of hypothesis testing
- Data interpretation and presentation
- Software tools for data analysis
    - MS Excel, MATLAB, SPSS, Python, and R

4. Technical Writing and Research Presentation

- Structure and components of technical reports and research papers
- Abstract, introduction, methodology, results, discussion, and conclusion

- Basics of thesis and dissertation writing
- Technical report formatting and documentation practices
- Preparation of research posters, seminar reports, and presentations
- Oral presentation and scientific communication skills

5. Intellectual Property Rights (IPR) and Innovation

- Introduction to Intellectual Property Rights
- Types of intellectual property
    - Patents
    - Copyrights
    - Trademarks
    - Industrial designs and geographical indications
- Basics of patent system and patent search
- Patent filing procedure and prior art search
- Technology transfer, innovation, and commercialization
- Case studies related to patents and IPR

References and Textbooks

1. Kothari, C. R., & Garg, G. – *Research Methodology: Methods and Techniques*, New Age International Publishers.
2. Creswell, J. W. – *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, SAGE Publications.
3. Montgomery, D. C. – *Design and Analysis of Experiments*, Wiley.
4. Gupta, S. C., & Kapoor, V. K. – *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons.
5. Day, R. A., & Gastel, B. – *How to Write and Publish a Scientific Paper*, Cambridge University Press.

6. Alley, M. – *The Craft of Scientific Presentations*, Springer.
7. Resnik, D. B. – *The Ethics of Science: An Introduction*, Routledge.
8. Narayanan, P. – *Intellectual Property Law in India*, Eastern Law House.
9. Bouchoux, D. E. – *Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets*, Cengage Learning.
10. Watal, J. – *Intellectual Property Rights in the WTO and Developing Countries*, Oxford University Press.