VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)

MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

(Revision 2018)
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, 2018-19

B. Tech Production Engineering

Programme Educational Objectives (PEOs):

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

Programme Outcomes:

1. Graduates will demonstrate basic knowledge in mathematics, science and engineering.
2. Graduates will demonstrate the ability to design and conduct experiments, interpret and analyze data, and report results.
3. Graduates will demonstrate the ability to improve a production process or system that meets desired specifications and requirements.
4. Graduates will demonstrate the ability to develop manufacturing friendly products and software packages by working with multidisciplinary teams and applying the knowledge gained during engineering and science laboratory classes.
5. Graduates will demonstrate the ability to identify, formulate and solve manufacturing related problems.
6. Graduates will demonstrate an understanding of their professional and ethical responsibilities.
7. Graduates will be able to demonstrate effective oral and written communication.
8. Graduates will have the confidence to apply engineering solutions in global and societal contexts.
9. Graduates will be capable of self-education and clearly understand the value of lifelong learning.
10. Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.
11. Graduates will be familiar with modern engineering software tools and equipment to analyze manufacturing related problems.

B. Tech. Production Engineering
Semester VII

Scheme of Instruction and Evaluation (R-2018)

Industrial Training and Project (R4PE 4901D)

Sr No	Course Code	Course Name	Hr / Week			Credits	Scheme of Evaluation		
			L	T	P		TA	MST	ESE
1	R4PE 4901D	Industrial Training and Project				18			

The Project work is evaluated at the end of seventh semester with an external examiner. The external examiner should be preferably from industry having minimum experience of five years.

Abbreviations:

L: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment, **MST**: Mid-Semester Test, **ESE**: End Semester Examination,

List of Open Elective 2

Sr. No.	Course code	Course Title
1.	R4PE4601S	Entrepreneurship Development

B. Tech. Production Engineering
Semester VIII

Scheme of Instruction and Evaluation (R-2018)

Sr No	Course Code	Course Name	Hr / Week			Credits	Scheme of Evaluation		
			L	T	P		TA	MST	ESE
1	R4PE4001S	Production and Operations Management	3	1	0	4	20	20	60
2	R4PE4002S	Supply Chain Management	3	1	0	4	20	20	60
3	R4PE4003S	Machine Tools Design	3	1	0	4	20	20	60
4	R4PE4004T	Operations Research	3	0	0	3	20	20	60
	R4PE4004P	Operations Research Lab	0	0	2	1	60		40
5	R4PE41xxS	Program Elective 2	3	0	0	3	20	20	60
6	R4PE41xxS	Program Elective 3	3	0	0	3	20	20	60
			18	3	2	22			

Abbreviations:

L: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment, **MST**: Mid-Semester Test, **ESE**: End Semester Examination.

List of Program Elective 2

Sr. No.	Course code	Course Name
1.	R4PE4101S	Unconventional and Micro Machining
2.	R4PE4102S	Refrigeration and Air Conditioning
3.	R4PE4103S	Composite Materials Processing Technology
4.	R4PE4104S	Computational Fluid Dynamics
5.	R4PE4105S	Operations Strategy
6.	R4PE4106S	Logistics Management
7.	R4PE4107S	Powder Metallurgy and Ceramics
8.	R4PE4108S	Additive Manufacturing
9.	R4PE4109S	Finite Elements Method for Manufacturing
10.	R4PE4110S	Product Design and Development

List of Program Elective 3

Sr. No.	Course code	Course Name
1.	R4PE4111S	Sales and Marketing
2.	R4PE4112S	Energy Management
3.	R4PE4113S	Flexible Manufacturing System
4.	R4PE4114S	Micro-Electro-Mechanical Systems (MEMS)
5.	R4PE4115S	Nano-Modeling and Applications: Molecular Dynamic Simulations
6.	R4PE4116S	Reliability Engineering
7.	R4PE4117S	Design for Manufacturing and Assembly
8.	R4PE4118S	Engineering Optimization
9.	R4PE4119S	Quality Engineering
10.	R4PE4120S	Product Life-cycle Management

Semester VII

Programme	B. Tech. (Production Engineering)	**Semester -** VII
Course Code	R4PE4901D	
Course Title	Industrial Training and Project	
Prerequisites	None	

Course Outcomes

To acquaint the student with overall functioning of an industrial organization, exposure to the organization structure, allied direct/indirect activities and procedures associated with the production function.

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

Learner will be able to…

1. Correlate with various technological trends, approaches and applications along with managerial exposure.
2. Appreciate and realize the size and scale of operations in Industry.
3. Apply their knowledge in problem solving and eventually develop that skill.
4. Demonstrate understanding of relevant application-oriented subjects in a better prospective.
5. Demonstrate understanding of various constraints of time and cost, within which goods are produced and services rendered in a specified quantum.
6. Describe the scope, functions and job responsibilities in various departments of an organization.
7. Bring in a visible change in their approach while dealing with technical and interpersonal issues.

Approach

The hands-on experience is essential to tackle real life problem, appropriate case study and investigative assignments. An investigative and analytical approach looking at a problem in it's entirely and not in isolation. The project report should contain problem definition and objective, background information, possible approaches and approach selected data identification, analysis or investigation carried out, results and concluding discussion. Develop skill in presenting a factual report on specification directed study stressing clarity, brevity and simplicity of styles.

	Areas The illustrative list of areas is given below is not exhaustive and it may extend to many more areas or combination thereof. 1. Process engineering and planning 2. Design and manufacture of production tooling. 3. Product / process innovation and development 4. Production Management 5. Quality control, SQC, SPC, TQM and rejection analysis. 6. Cost reduction, value engineering/analysis, method improvement, productivity analysis and improvement, layout and material handling investigation. 7. Industrial engineering and operations research 8. Any problem involving analysis and investigation in production technology, inventory, plant engineering maintenance, stored and purchase, process and tool engineering. (In line with Production Engineering Syllabus of VJTI).
	Guidelines for Evaluation The total duration for each presentation shall be maximum 45 minutes, inclusive of 35 minutes for presentation and 10 minutes for discussion. The marks to be awarded based on the points furnished below and as per the discretion of the internal project guide. 1. Content of the presentation. 2. Presentation skill. **3.** Interest taken, personal involvement and contribution. 4. Progress made in the project execution.
	Evaluation/Assessment of the Term Work 1. Introduction, Acknowledgements, references. 2. Company background/ activities. 3. Training areas / Training details. 4. Synopsis / Abstract of the Project. 5. General presentation, neatness and accuracy of the data furnished. 6. Technical contents of the report with data / observations, graphs, drawings, etc. 7. Quality of work carried out and details furnished based on personal Observations/involvement. 8. Result/ Conclusion.

Open Elective 2

Programme	B. Tech. (All Branches)	**Semester -** VII
Course Code	R4PE4601S	
Course Title	Entrepreneurship Development	
Prerequisites	None	

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

1. Describe what it takes to be an entrepreneur
2. Analyze business opportunities and the basics to create, launch and manage new businesses
3. Develop Business Model for their Idea/Problem
4. Create MVP (Minimum Viable Product).

Syllabus

1.	**Introduction** Discover yourself – Find you Flow, Effectuation, Identify your entrepreneurial style
2.	**Problem Identification and Idea generation** Identify Problems worth Solving, Introduction to Design Thinking, generate ideas that are potential solutions to the problem identified, GOOTB: Run problem interviews with prospects, Class Presentation: Present the problem you "love", Team Formation.
3.	**Customer Study and Value Proposition** Identify Your Customer Segments and Early Adopters - Market Types, Segmentation and Targeting, Defining the personas; Understanding Early Adopters and Customer Adoption Patterns, Customer identification, Market, Creative solution; Craft Your Value Proposition - Come up with creative solutions for the identified problems, Deep dive into Gains, Pains and "Jobs-To-Be-Done" (using Value Proposition Canvas, or VPC), Identify the UVP of your solution using the Value Proposition section of the VPC, Outcome-Driven Innovation.

4.	**Business Model Canvas** Get Started with Lean Canvas - Basics of Lean Approach and Canvas; Types of Business Models (B2B; B2C), Sketch the canvas- "Document your Plan A", Intro to Risks; Identify and document your assumptions (Hypotheses); identify the riskiest parts of your Business Plan, Risk identification, Class Presentation: Present your Lean Canvas.
5.	**Validation** Develop the Solution Demo - Build solution (mock-ups) demo, How to run solution interviews, GOOTB: Run Solution interviews, Does your solution solve the problem for your customers: The problem-solution test. Sizing the Opportunity - Differences between a Start-up venture and a small business; Industry Analysis: Understanding what is Competition and its role, Analyse competition; Building an MVP - Identification of MVP, Solution development, building products/services, Build-measure-learn loop for development
6.	**Money** Revenue streams, Pricing and cost, Financing Your New Venture - Venture financing, Investor expectations .
7.	**Team building** Shared leadership, role of good team, how to pitch to candidates to join your startup Collaboration tools and techniques - Brainstorming, Mind mapping, Kanban Board, #Slack
8.	**Marketing and sales** Positioning of Product/Services, Channels and strategies, Building Digital Presence and leveraging Social media, Budgeting and planning. Sales planning - Buying decisions, Sales planning, setting targets, Unique Sales Proposition (USP); Art of the sales pitch (focus on customers' needs, not on product features), Follow-up and closing a sale; Asking for the sale.
9.	**Support** Planning and tracking - Importance of project management to launch and track progress, Understanding time management, workflow, and delegation of tasks. Business Regulation - Basics of business regulations of starting and operating a business; Importance of being compliant and keeping proper documentation; How to find help to get started.

	Text Books
1.	Roy R.: Entrepreneurship, Oxford University Press.
2.	Maurya A.: Running Lean: Iterate from Plan A to a Plan That Works. O'Reilly Media
	References
1.	Jeffry A: New venture creation, Tata McGraw Hill
2.	Osterwalder, A and Pigneur Yves: Business Model Generation: A Handbook for Visionaries, Game Changers and Challengers.
3.	Gupta T. S: Intellectual Property Law in India, Kluwer Law International.
4.	Saraswathi S.D: Effectuation: Elements of Entrepreneurial Expertise. Edward Elgar Publishing.
5.	Kim W. C. and Mauborgne R: Blue Ocean Strategy, Harvard Business School Press.
6.	Ries, E.: The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, The Crown Publishing Group

Semester VIII

Programme	B. Tech. (Production Engineering)	**Semester -** VIII
Course Code	R4PE4001S	
Course Title	Production and Operations Management	
Prerequisites	Applied Probability and Statistics (R4PE2006S), Industrial Engineering (R4PE3006S)	

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

1. Demonstrate understanding of operation flow, primary and supporting activities to achieve quality and economical products.
2. Apply analytical knowledge in the areas of strategic, operational decision making preferably using quantitative methods and computers.
3. To develop analytical competency for production planning and control in manufacturing discrete products.
4. Demonstrate applications of latest trends in POM.

Syllabus

Note: Employ case study approach to teach the topics particularly HBS case studies like Mahindra Scorpio and Tata Nano motor development.

1. **Introduction**

Understanding products, goods and services; function, objectives, activities and organization of production; Transformation process model: Inputs, process and outputs; Strategic and tactical decisions. Evolution of POM. Classification of operations/ production system - Process types in manufacturing: project, jobbing, batch, line, mass, continuous; Process types in services: professional services, services shops, mass services; Operations Strategy; Trends in Operations Management

New Product Development, Selection and Design of Product / Services. Break-even analysis for process, plant and equipment selection.

2. **Product Design and Development**

Classification of products. Definition of product design, Design by evolution, innovation, Various phases in product development and Design, Morphology of Design, Considerations in product design, Product specifications. DFMA. Value engineering and analysis - Material and process selection in value engineering, Cost reduction, case studies and exercises.

3.	**Production System Design** Product Strategy and integrated product development. Process Strategy. Facility Location: Location Strategies and its Importance; Factors influencing Plant Location; Globalization; Location Selection Models Layout Planning: Layout Types; Design of Product and Process Layouts; Job Design; Work Measurement. Group Technology, Flexible Manufacturing system. Assembly line balancing (Mixed model line balancing, Current thoughts on assembly lines, Computerized assembly line balancing). Line of Balance (LOB).
4.	**Production Planning and Control (PPC)** Production planning and Control functions. Techniques for various process choices, production control and aggregate planning. Demand Forecasting: Methods- Dependent demand and independent demand. Qualitative and Quantitative, Forecast accuracy. Aggregate Production Planning (APP) and its methods; Master Scheduling; Aggregate capacity planning. Aggregate Planning for Service Organizations Material Requirement Planning: Introduction, Master production schedule, Bill of material, Product structure, Ingredients of MRP, MRP calculations, concept of MRP-II. Basics of ERP. Scheduling, sequencing and dispatching: Objectives in scheduling, Loading, Sequencing, algorithms for scheduling. Monitoring, Advanced Planning and Scheduling Systems, Theory of Constraints, Employee scheduling. Operating Schedules; Sequencing Rules; Optimized Production Technology and Synchronous Manufacturing; Just in Time (JIT) Manufacturing System.
5.	**Logistics and Supply Chain Management** Basics of SCM and logistics. Material Management: Introduction, Importance and objectives, Purchasing and Stores: policies and procedures; Vendor selection policies and methods, rating analysis, development. Selective inventory control- ABC, VED, XYZ, HML, FSN. Inventory control systems: Deterministic and probabilistic economic order quantity (EOQ) models, Quantity discounts, Reorder point, Order quantity for a periodic order system. Newsvendor models. Dynamic lot sizing.
6.	**Maintenance** Types of maintenance for facilities and equipment; Preventive versus breakdown maintenance; principles of preventive maintenance; Procedure for maintenance; Time of failure; Reliability and machine availability trade off, concepts of MTBF, MTTR and MWT and factors of availability; total productive maintenance (TPM).

7.	**Evolutionary Operations Methodology (EVOP)** Overview and Rationale, Statistical basis, Experimental design, One/Two/Three factor EVOP designs
	Text Books
1.	B. Mahadevan: Operations Management, Pearson India Education, New Delhi.
2.	Chase Richard, Ravi Shankar and J. Robert: Operations and Supply Chain Management, McGraw Hill India.
	References
1.	Joseph Metternich: Production and Operations Management, Wiley India.
2.	Lee Krajewski, Manoj Malhotra and Larry Ritzman: Operations Management - Processes and value chains, Pearson Education.
3.	Steven Nahmias and Tava Olsen: Production and Operations Analysis, 2020 Waveland Press.
4.	Samuel Elion: Elements of Production Planning and Control, Universal Publication.
5.	S.N. Chary: Production and Operations Management, TMH.
6.	Chopra, Meindl, and Kalra: Supply Chain Management, Pearson Education.
7.	K. Otto and K. Wood: Product Design, Pearson Education.
8.	Janat Shah: Supply chain Management, Pearson Learning.

Programme	**B. Tech. [Production Engineering]**	**Semester -** VIII
Course Code	R4PE4002S	
Course Title	Supply Chain Management	
Prerequisites	Applied Probability and Statistics (R4PE2006S),	

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

1. Apply key concepts of supply chain management to Analyze and improve supply chain processes.
2. Apply knowledge to evaluate and manage an effective supply chain.
3. Understand the foundational role of logistics as it relates to transportation and warehousing.
4. Align the management of a supply chain with corporate goals and strategies.

Syllabus

1.	**Building a Strategic Frame work** Supply chain stages and decision phases, Process view of supply chain: Supply chain flows, Examples of supply chains, Competitive and supply chain strategies, achieving strategic fit: Expanding strategic scope, Drivers of supply chain performance. Framework for structuring drivers: inventory, transportation facilities, information obstacles to achieving fit. Supply Chain Performance, Supply Chain Drivers and Metrics
2.	**Designing the Supply Chain Network** Distribution Networking: Role, Design, Supply chain network (SCN): Role, Factors, framework for design decisions.
3.	**Inventory Management** Scope, Importance, Classification of materials, Procurement, Purchasing policies, Vendor development and evaluation. Inventory control systems of stock replenishment, Cost elements, EOQ and its derivative modules.
4.	**Logistics Management** Introduction: A macro and Micro Dimensions, Logistics interfaces with other areas, Approach to analyzing logistics system, Logistics and systems analyzing: Techniques of logistics system analysis, factors affecting the cost and Importance of logistics.
5.	**Warehouse and Transport Management** Concept of strategic storage, Warehouse functionality, Warehouse operating principles, Developing warehouse resources, Material handling and packaging in warehouses, Transportation Management, Transport functionality and principles, Transport infrastructure, transport economics and Pricing. Transport decision making

6	**IT in Supply Chain** IT framework, Customer Relationship Management (CRM), internal Supply chain management, Supplier Relationship Management (SRM), Transaction management, **Supply Chain Coordination** Lack of supply chain coordination and the Bullwhip effect, Obstacle to coordination, Managerial levers, Building partnerships and trust. **Emerging Trends and Issues** Vendor managed inventory-3PL-4PL, Reverse logistics: Reasons, Role, Activities; RFID systems: Components, Applications, Implementation; Lean supply chain, Implementation of Six Sigma in supply chain, Green supply chain.
	Text Books
1.	Chopra Sunil, Meindl Peter and Kalra D.V: Supply Chain Management: Strategy, Planning & Operation, Pearson Prentice Hall.
2.	Janat Shah: Supply Chain Management: Texts & Cases, Prentice Hall.
	References
1.	David Simchi Levi, Philip Kaminsky and Edith Smichi Levi: Designing and Managing Supply chain, TMH.
2.	Narayan Rangaraj, G Raghuram, Mandyam M Srinivasan: Supply Chain Management for Competitive Advantage- Concepts & Cases TMH

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4003S	
Course Title	Machine Tools Design	
Prerequisites	Theory of Machines (R4PE3001S), Machine Design (R4PE3001S)	

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

1. design of stepped speed gear box and step less speed of machine tools
2. design various machine tool elements by application of design principles
3. design of stepped speed gear box and step less speed of machine tools
4. design different control system in machine tool.

Syllabus

1. **Introduction**

Recent trends in machine tool design, Classification and kinematic structure of machine tool.

Principles of machine tool design for strength and rigidity of machine tool structures, optimum criteria for machine tool structure, functions of machine tool structures and their requirements. Materials of machine tool structures; static and dynamic stiffness, static compliance of machine tool; profiles of machine tool structures

Basic design procedure of machine tool's structure design of lathe bed, bending strength of bed cross sections, Torsional modules of box sections, design for Torsional rigidity, methods of increasing rigidity, reinforcing stiffness, design of pillar drill column, radial drill column; force analysis of a shaping machine, deflection of column, analysis and design of tail stock assembly.

2. **Design of Machine Tool Drives**

Mechanical drives for providing rotational movement, basic principles, stepped and stepless output, requirements for layout of a stepped drive, selection of range of spindle speeds, velocity range for high-speed machining, construction of speed diagram, analysis of productivity loss, layout of speeds in arithmetic progression (A.P.) and geometric progression (G.P.) only; introduction to L.P. modeling. Kinematic advantages of G.P. series, selection of values of common ratio and design of gear boxes for feed and speed having 4 to 12 speeds only using geometric progression series; belt and cone pulley drive

Feed drive types, Friction variator- Principle and types

3.	**Design of machine tool elements** **Design of bed-** Optimum design criteria, Cross sections, stiffness, Materials, Column design methodology for radical drilling and milling machine. **Design of guides**-materials, Requirements, Types, Average pressure, stability, wear and it's compensation, Combination guide, stick-slip. **Design of spindle**- Material, spindle ends and supports, Spacing between supports. **Design of clutches and power screws -** Selection and application principles, design of power screws, types, selection and error compensation; elementary treatment of re-circulating ball screws. Axial load and dynamic load carrying capacity, Rigidity etc. **Machine Tool Bearings** Journal, rolling element and hydrostatic bearings, basic principles of selection of bearing; assembly, maintenance and mounting techniques **Vibration** Free vibration, forced damped vibration in machine tools
4.	**Hydraulic Drives and their Stepless Drives:** Advantages, hydraulic pumps, vane pump, fundamentals, elementary hydraulic circuits, various types of valves for hydraulic systems such as pressure control valve, piston type relief valve, compound relief valve, pressure reducing valve, throttle valve and their features; pressure compensated flow control valve , rotary spool type directional control valve, 4 way, 2 position and 2 way, 2 position, 4 way, 3 position, 4 way spool valves, metering in and metering out circuits, servo controls and their symbolic representation, simple hydraulic circuits of shaping, Planning and grinding machines only.
5.	**Acceptance Tests on Machine Tools** Safety, concepts, performance test, geometrical test of lathe, drilling, milling and shaping machines only, maintenance, ergonomic and aesthetic aspects of machine tool.
6.	**NC- CNC AND FMS** Introduction, Block diagram of NC, Tool motion, Axes designation, CNC block diagram, Open/ Close loop control, Sensors, FMS- definition, Classification, Automatic tool changer, Machining centres.
7	**Micro movement and reliability of machine tool** Micro movement method- Magnetostrictine, Thermodynamic etc, Reliability of component, Condition based maintenance and reliability centric maintenance**.**

	Text Books
1.	A. Bhattacharya and G.C. Sen, Principles of Machine Tools, New Central Book Agency, Calcutta
2.	D.K. Pal and S.K. Basu, Design of Machine Tools, Oxford-IBH .
	References
1.	Mehta, N.K., Machine Tool Design, Tata McGraw Hill.
2.	Martin, S.J. NC Machine Tools, ELBS
3.	T Kundra, Rao, P.M., Tiwari, N.K. Numerical Control and Computer Aided Manufacturing, Tata McGraw Hill
4.	Nagpal G R: Machine Tools Design, Khanna Publishers

Programme	B. Tech. (Production Engineering)	**Semester -** VIII
Course Code	R4PE4004T	
Course Title	Operations Research	
Prerequisites	Mathematics for Production Engineers (R4MA2002S), Applied Probability and Statistics (R4PE2006S)	

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

1. Identify and formulate OR models from the verbal description of the real system.
2. Apply the mathematical tools that are needed to solve optimization problems and Conduct and interpret post-optimal and sensitivity analysis.
3. Use computer software to solve the proposed models - use LINGO, and EXCEL for integer and nonlinear programming problems and use WINQSB, QM and TORA to solve network models and games.
4. Develop a report that describes the model and the solving technique, analyses the results and propose recommendations in language understandable to the decision-making processes in Management Engineering.

Syllabus

1.	**Modelling and Linear Programming Problems (LPP)** Introduction to modelling and OR- scope, approach and limitations. LPP – Model Formulation. Solution using graphical method, Simplex method, Big−M method, Two−phase method, Principle of Duality, Dual Simplex, Sensitivity Analysis. Transportation and transshipment problem**:** Formulation, initial solution and optimal solution, Degeneracy. Assignment problem**:** Formulation - Optimal solution, Traveling Salesman problem.
2.	**Integer and Dynamic Programming** Gommery's cutting plane technique, branch and bound algorithm (BBA) for integer programming problems, zero one algorithm. Dynamic programming: Introduction – Bellman's Principle of optimality - Applications of dynamic programming- capital budgeting problem.
3.	**Queuing/ Waiting line theory** Introduction – Queuing system and their characteristics. The M/M/1 Queuing system, Steady state performance analyzing of M/M/ 1 and M/M/C queuing model.

4.	**Game Theory** Introduction - Formulation of games, two person-Zero sum game. Minimax (Maximin) - Criterion and optimal strategy - Solution of games with saddle points – Rectangular games without saddle points - 2 X 2 games - dominance principle - m X2 & 2 X n games, Graphical method.
5.	**Network analysis and project Management** Network terminology. Solution algorithms for shortest Path problem. Maximum flow problem. Minimum Spanning Tree. Program Evaluation and Review Technique, Critical Path Method, Network Updating, Crashing of Network and Resources leveling.
6.	**Replacement** Introduction - Replacement of items that deteriorate with time - when money value is not counted and counted - Replacement of items that fail completely, group replacement.
7.	**Engineering optimization and MCDM** Introduction to Optimization, Single and Multivariable optimization methods, constrained optimization methods. Advanced optimization methods including; Genetic Algorithm, Simulated Annealing, Particle Swarm Optimization. Basics of multi-criteria decision making. Analytical Hierarchy Process, Weighted Product Method, Analytical Network Process, Technique for Order Preference and Similarity to Ideal Solution (TOPSIS).
8.	**Simulation** Definition - Types of simulation models - phases of simulation –Monte Carlo simulation applications of simulation – Inventory, production and Queuing problems - Advantages and Disadvantages.
	Text Books
1.	J.K. Sharma: Operations Research, McMillan Publishing.
2.	Hillier, Lieberman, Nag, and Basu: Introduction to Operations Research, McGraw Hill.
	References
1.	Winston Wayne: Operations Research, Cengage Learning.
2.	Hamady Taha: Operations Research, Pearson Learning.
3.	Ravindran and Phillips: Operations Research: Principle and Practices, Wiley India.
4.	N.D. Vohra: Quantitative Techniques in Management, TMH.

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4004P	
Course Title	Operations Research Lab	
Prerequisites	Mathematics for Production Engineers (R4MA2002S), Applied Probability and Statistics (R4PE2006S)	

	Syllabus
1.	It includes areas of optimization, probability and simulation to model, analyze and control complex systems. Using the optimization software like TORA, Excel Solver, MATLAB, LINDO & LINGO, and Simulation Software student should able to perform the experiment: 1. Formulation of at least six different types of linear and solving using Excel. 2. To find the number of units to ship from each factory to each customer that minimizes the total cost. It includes both transportation and transshipment problem 3. To find the assignment of persons to tasks that minimizes the total cost. 4. To find the **shortest path** from node S to node T in an undirected network. 5. To find the **maximum flow** from node S to node T in a directed network. 6. To find the combination of **capital investments** that maximizes the total profit 7.Solving industrial problems based on MCDM
	Text Books
1.	J.K. Sharma: Operations Research, McMillan Publishing.
2.	Hillier, Lieberman, Nag, and Basu: Introduction to Operations Research, McGraw Hill.
	References
1.	Winston Wayne: Operations Research, Cengage Learning.
2.	Hamady Taha: Operations Research, Pearson Learning.
3.	Ravindran and Phillips: Operations Research: Principle and Practices, Wiley India.
4.	N.D. Vohra: Quantitative Techniques in Management, TMH.

Program Elective 2

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4101S	
Course Title	Unconventional and Micro Machining	
Prerequisites	Machining and Process Engineering (R4PE3003T), Metallurgy and Materials Technology (R4PE3005S)	

	Course Outcomes: On the completion of this course, the learner will able to 1. Demonstrate the capabilities of micro and nano mechanical manufacturing system 2. Apply knowledge to electronic device fabrication 3. to employ CAD in Nano Design and VLSI 4. design and improve products based on nano technology.
	Syllabus
1.	**Scope of Nano Technology** Nano technology Concepts and Applications, Micro and Nanofabrication, Nano technology in India. Scope for Micro-fabrication, Rise Nano technology Fields, Commercialization Issues of Micro - Nano Technology.
2.	**Micro-fabrication** Mechanical Micromachining, Physical Fabrication Methods, Lithography, Processing Setup, Nano Lithography & Manipulation, Precision Micro- and Nano-grinding, Use of Spectrometers & Microscopes
3.	**Laser-Based Micro- and Nanofabrication** Pulsed Water Drop Micromachining, Nano Materials, Synthesis of Nano materials, Bio Materials, Nano Composites, Development of Nano Particles
4.	**Innovative Applications on Present Devices** Nano-chips, Nanotubes and Nanowires, Integration of chips and microprocessors, Technology Support, Meeting Social Needs
5.	**Nano Design & CAD** Computer Aided Nano Design, VLSI product detailing, Finite Element Analysis of Microstructures, 3-D Molecular Modelling.
	Text Books
1.	Mark J. Jackson: Micro-fabrication and Nano-Manufacturing, Taylor and Francis Group.
	References
1.	ASM: Handbook on Machining Vol. XVI

Programme	B. Tech [Production Engineering]	**Semester: VIII**
Course Code	R4PE4102S	
Course Title	Refrigeration and Air Conditioning	
Prerequisites	Applied Thermodynamics (R4PE2007T)	

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

1. Discuss fundamental refrigeration and air conditioning principles
2. Identify and locate various important components of the refrigeration and air conditioning system
3. Illustrate various refrigeration and air conditioning processes using psychometric chart.
4. Design and analyse complete air conditioning system

Syllabus

1. **Introduction to Refrigeration**

Methods of refrigeration, First and Second Law applied to refrigerating machines, Carnot refrigerator, Carnot heat pump, unit of refrigeration, Co-efficient of Performance, Energy Efficiency Ratio (EER), BEE star rating. Air refrigeration systems: Bell Coleman cycle, applications. Aircraft air refrigeration systems: Need for aircraft refrigeration, Simple, Bootstrap including evaporative cooling, reduced ambient, Regenerative air-cooling system, Comparison of these systems based on DART rating.

2. **Vapour Compression Refrigeration System**

Simple vapour compression cycle, Effect of liquid sub-cooling & superheating, effect of evaporator and condenser pressures, methods of sub-cooling, use of P-h charts, Actual VCR cycle, Two stage VCR cycle with Water intercooler, flash intercooler & liquid sub-cooler, multi-evaporators at different temperatures with individual/compound compressors and individual/multiple expansion valves. Types of condensers, evaporators, expansion devices and Compressors. Use of enhanced surface tubes in Heat Exchangers. Cooling tower: Types of cooling towers, tower approach, tower range, tower efficiency, tower losses, tower maintenance. Refrigerants- Desirable properties of refrigerants, ASHRAE numbering system for refrigerants. Thermodynamic, Chemical and Physical properties. Secondary refrigerants, ODP and GWP, Montreal protocol and India's commitment, Recent substitutes for refrigerants.

3. **Vapour Absorption Refrigeration**

Importance of VAR system, COP of ideal VAR system, Ammonia-water VAR system, Lithium Bromide – Water VAR system, Single and double effect, Electrolux refrigeration system. Solar VAR system. Nonconventional Refrigeration Systems: Thermoelectric Refrigeration, Thermo acoustic Refrigeration, Vortex Tube Refrigeration

4.	**Psychrometry** Need for air conditioning, Principle of psychrometry, Psychrometric properties, chart and processes, air washers, requirements of comfort air conditioning, summer and Winter Air conditioning.
5.	**Design of Air Conditioning Systems** Different Heat sources, - Adiabatic mixing of two air streams, Bypass factor, sensible heat factor, RSHF, GSHF, ERSHF, Room apparatus dew point and coil apparatus dew point, Ventilation and infiltration, Inside and Outside Design condition, Cooling Load estimation, Introduction to Unitary Products viz. Room/Split and Packaged Air Conditioners, Introduction to recent developments viz. Variable Refrigerant Flow systems, VAV control systems, Inverter Units. Human Comfort, Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone.
6	**Duct Design and Applications** Friction chart for circular ducts. Equivalent diameter of a circular duct for rectangular ducts, Static pressure regain and equal pressure drop methods of duct design, Factors considered in air distribution system, Air distribution systems for cooling & heating, Controls – LP/HP cut-off, Thermostats, Humidistats, Interlocking control, Electronic Controllers. Applications Refrigeration & A/C Ice plant – food storage plants – diary and food processing plants, Food preservation , Freeze Drying, A/c in textile ,printing pharmaceutical industry and Hospitals , Liquefaction of LNG, Liquefaction of gases (cryogenics), Deep sea water air-conditioning.
	Text Books
1.	C P Arora: Refrigeration and Air-Conditioning, TMH
2.	R J Dossat: Principles of refrigeration, Willey Eastern Publication.
	References
1.	W F Stoker and J W Jones: Refrigeration and Air Conditioning, TMH.
2.	C P Arora: Modern Air-conditioning Practice, TMH.

Programme	B. Tech (Production Engineering)	Semester - VIII
Course Code	R4PE4103S	
Course Title	Composite Materials Processing Technology	
Prerequisites	Applied Physics-II (R4PH 1021T), Metallurgy and Materials Technology (R4PE3005S)	

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

1. Understand the basic composite material processes involved in the manufacturing of Composites methods and its application.
2. Apply the strengthening mechanism of composite and its corresponding effect on performance and application;
3. Analyze theoretical basis of the experimental techniques utilized for failure mode of composites and develop expertise on the applicable engineering design of composite.
4. Evaluate design and fabrication of composite materials for structural application

Syllabus

1. **Introduction**

Definitions. Typical reinforcements and matrices. Typical properties of fiber composites; mechanical, weight, chemical resistance, etc., compared with "standard" materials. Particular composites. Quality assurance, outline of manufacturing methods. Economic aspects. Dependence of properties on manufacturing route; typical manufacturing defects. Applications. Fiber strengthening; fiber flaws, critical length, critical volume fraction. Natural composites (wood, bone, etc.).

2. **Fibers**

Manufacturing methods. Physical and chemical characteristics. Mechanical and other properties of commonly used fibers - carbon, glass, aramid and other organics, ceramics. Fiber coating to achieve compatibility with matrix. Use of statistical methods to characterize fiber behaviour. Naturally-occurring (cellulose) fibers. Whiskers; typical properties, manufacturing methods.

3. **Manufacturing of Polymer Matrix Composites**

Principles of manufacturing processes (open and closed mould), including: hand and spray lay-up, press molding, injection molding, resin injection, RRIM, filament winding, pultrusion, centrifugal casting, autoclave, prepreg and other "starting" materials, etc. Machine methods for manufacture of composites. Cutting, drilling and other finishing operations.

4. **Fiber-Matrix Interface**

Theories of adhesion; absorption and wetting, inter diffusion, electrostatic, chemical, mechanical. Measurement of interface strength. Characterization of particular systems; carbon fiber /epoxy, glass fiber/polyester, etc. Influence of interface on mechanical properties of composite.

5.	**Plastic Matrix Systems** Thermoplastic and thermosetting resins; curing reactions, mechanical properties, glass transition, degradation. Carbon fiber/epoxy, carbon fiber/PEEK, glass fiber/polyester. Short fiber reinforced Nylon 6-6, polypropylene and polycarbonate. Glass and Ceramic Matrix Systems: Glasses and ceramics; hot pressing and sintering, vapour phase transport, mechanical and electrical properties. Carbon fiber/carbon. Silicon carbide fiber/lithium alumino-silicate glass. Silicon carbide whiskers in silicon nitride and in alumina. Silicon carbide fiber in silicon carbide. Alumina fibers in lithium aluminosilicate glass.
6	**Metal Matrix Systems** Metals and alloys; solidification processes, diffusion bonding, mechanical properties. Boron fiber reinforced aluminium and titanium alloys. Alumina fiber reinforced aluminium alloys. Silicon carbide fiber reinforced aluminium alloy. Particulate systems.
7.	**Engineering Properties** Geometrical aspects, volume and weight fraction. Unidirectional continuous fiber systems; stiffness and strength. Discontinuous fibers. Short fiber systems; length and orientation distributions. Woven reinforcements. Hybrids. Failure theories for unidirectional lamina. Micro mechanics theories. Mechanical Testing: Determination of stiffness and strengths of unidirectional composites; tension, compression, flexure and shear. Typical standard methods. Use of photo elastic, holographic and other methods of strain measurement.
8.	**Joining** Advantages and disadvantages of adhesively bonded and mechanically fastened joints. Details of typical bonding procedures. Typical strengths; test procedures. Stress analyses. Repair.
9.	**Design, Economics and Environment** Design philosophy and procedures ("systems approach"). Simple design studies (pressure vessels, torsion bar, etc.); factors of safety. Use of computer programs and other methods. Case studies to illustrate reasons for failure, design process, materials selection, manufacturing method. (Industrial lectures). Economic aspects of using composites. Environmental Effects**:** Influence of moisture and other contaminants on fiber, matrix an interface. Effect on mechanical and other properties. stress corrosion cracking. Influence of high and low temperatures. Prediction of long-term behaviour.

10.	**Nanocomposite** Nanomaterial properties, effect on Mechanical properties, manufacturing of Nanocomposite and application.
	Text Books
1.	Ever J Barbero: Introduction to Composite Materials Design, Taylor and Francis.
2.	Robert Jones: Mechanics of Composite Materials, Taylor and Francis.
	References
1	P. K Mallick: Fiber Reinforced Composite Materials, Manufacturing, and Design, CRC Press
2.	Mechanics of Composite Materials: Robert M. Jones, Taylor and Francis Group.
3.	F C Campbell: Manufacturing Process for Advanced Composites, Elsevier Ltd.
4.	Venkatesan (Ed): Composites and Processing Methods, Narosa Publications

Programme	B. Tech (Production Engineering)	**Semester:** VIII
Course Code	R4PE4104S	
Course Title	Computational Fluid Dynamics	
Prerequisites	Fluid Mechanics and Machinery (R4PE2008T)	

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

1. Understand solution of aerodynamic flows. Appraise & compare current CFD software. Simplify flow problems and solve them exactly
2. Define and setup flow problem properly within CFD context, performing solid modelling using CAD package and producing grids via meshing tool
3. Understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution
4. Use CFD software to model relevant engineering flow problems. Analyze the CFD results. Compare with available data, and discuss the findings.

Syllabus

1. **Introduction**

Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description.

Classification and Overview of Numerical Methods: Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions; over view of numerical methods.

2. **Finite Difference Technique**

Finite difference methods; different means for formulating finite difference equation; Taylor series expansion, integration over element, local function method; treatment of boundary conditions; boundary layer treatment; variable property; interface and free surface treatment; accuracy of f.d. method.

3. **Finite Volume Technique**

Finite volume methods; different types of finite volume grids; approximation of surface and volume integrals; interpolation methods; central, upwind and hybrid formulations and comparison for convection-diffusion problem.

4. **Finite Element Methods**

Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one- and two-dimensional elements; applications.

Methods of Solution: Solution of finite difference equations; iterative methods; matrix inversion methods; ADI method; operator splitting; fast Fourier transform.

5.	**Time integration Methods** Single and multilevel methods; predictor corrector methods; stability analysis; Applications to transient conduction and advection diffusion problems.
6.	**Numerical Grid Generation** Numerical grid generation; basic ideas; transformation and mapping. Navier-Stokes Equations: Explicit and implicit methods; SIMPLE type methods; fractional step methods.
7	**Turbulence Modeling** Reynolds averaged Navier-Stokes equations, RANS modeling, DNS and LES.
	Text Books
1.	Anderson, Tannehill and Pletcher: Computational Fluid Mechanics and Heat Transfer, Taylor & Francis.
	References
1.	Ferziger and Peric: Computational Methods for Fluid Dynamics, Springer Verlag, Berlin.
2.	Versteeg and Malalasekara: Introduction to Computational Fluid Dynamics: The Finite Volume Method, (Indian Reprint) Pearson Education.

Programme	B. Tech [Production Engineering]	**Semester:** VIII
Course Code	R4PE4105S	
Course Title	Operations Strategy	
Prerequisites	None	

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

1. Apply principles of competitive strategy to different industries.
2. Determine which outputs win orders in the market best suited to produce those results.
3. Select appropriate operations strategy for competitive advantage.
4. To examine process improvement programs for gaining competitive advantage.

Syllabus

1. **Principles of Strategy**

   Principles of competitive strategy, partnerships, challenges, and responses. Introduction, need and concepts of operations strategy and links with corporate strategy.
   Operations Strategy in a Factory**:** Manufacturing Outputs and Production Systems, Manufacturing Levers and Capability.

2. **Competitive Analysis**

   Selecting the Best Production System. Framework for Manufacturing Strategy -Process of formulation and implementation. Emerging theory of manufacturing. Time the new source of competitive strategy. Competing through manufacturing.

3. **Operations Strategy in an International network of factories**

   Principles of international competitive strategy, manufacturing in the world's major trading regions, manufacturing networks, network outputs, levers and capability, factory-types in international manufacturing networks.

4. **Programs used frequently in Operations strategy**

   Operations Strategy and Business Strategy. Integrating Operations strategy with business strategy -Improvement programs in operations, Focus, soft technologies, hard technologies, benefits of experience and the product life cycle, Evaluation of investments in manufacturing. Seven Production Systems for Focused Factories
   Job shop production system, Batch flow production system, Flexible manufacturing system, Operator-paced line flow production system, Just-in-Tine production system, Equipment-paced line flow production system, Continuous flow production system.

	Text Books
1.	Nigel Slack and Michael Lewis: Operations Strategy, Pearson Learning
	References
1.	Robert Hayes, Gary Pisano and David Upton: Strategic Operations, Competing through Capabilities. The Free Press
2.	John Miltenburg: Manufacturing Strategy, Taylor and Francis.
3.	Terry Hill: Manufacturing Strategy, McGraw-Hill, Irwin Inc.

Programme	B. Tech. (Production Engineering)	**Semester - VIII**
Course Code	R4PE4106S	
Course Title	Logistics Management	
Prerequisites	None	

	Course outcomes 1. Develop an understanding of the role of logistics in a market-oriented society 2. Examine the major functions of logistics 3. Provide an opportunity for comprehensive analysis and discussion of key contemporary issues and problems in logistics management 4. Examine the details of planning and control processes in logistics management
	Syllabus
1.	**Concept of Logistics** Introduction, Objectives, Concept of Logistics, Objectives of logistics, Types of logistics, Concept of Logistics Management, Evolution of Logistics, Role of Logistics in an Economy, Difference between Logistics and Supply Chain Management, Logistics and Competitive Advantage, Logistics Mix, Logistics in Organized Retail in India.
2.	**Integrated Logistics** Introduction, Objectives, Concept of Integrated Logistics, Inventory flow, Information flow, Operational Objectives of Integrated Logistics, Barriers to Integration, Organization structure, Measurement system, Inventory ownership, Information technology, Knowledge transfer capability, Logistical Performance Cycle, Logistics performance cycle, Manufacturing support performance cycle, Procurement performance cycle
3.	**Material Handling**: Introduction, Objectives, Concept of Material Handling, Objectives of material handling, Principles of material handling, Equipment Used for Material Handling, Points to be Considered While Handling Materials, Role of Material Handling in Logistics.
4.	**Material Storage System:** Introduction, Objectives, Concept of Material Storage System, Unit Load Storage, Storage principles, Storage design and its benefits, Storage Methods

5.	**Warehousing:** Introduction, Objectives, Concept of Warehousing, Need for warehousing management, Evolution of warehousing, Functions of Warehouses, Types of Warehouses, Warehousing Cost, Warehousing Strategies, Significance of Warehousing in Logistics, Warehousing Management System (WMS)
6.	**Logistical Packaging**: Introduction, Objectives, Concept of Logistical Packaging, Design Consideration in Packaging, Types of Packaging Material, Packaging Costs
7.	**Transportation:** Introduction, Objectives, Transportation System, Transportation Infrastructure, Different Modes of Transportation, Freight Management, Factors Affecting Freight Cost, Transportation Network, Containerization.
8.	**Logistics Outsourcing**: Introduction, Objectives, Concept of Logistics Outsourcing, Catalyst for logistics outsourcing, Benefits of logistics outsourcing, Issues in logistics outsourcing, Third -Party Logistics, Fourth-Party Logistics, Selection of Logistics Service Provider, Logistics Service Contract, Outsourcing-Value Proposition
9.	**Logistics Information System***:* Introduction, Objectives, Concept of Logistics Information System (LIS), Importance of LIS, Principles of designing LIS, Logistics Information Architecture, Application of Information Technology in Logistics and Supply Chain Management
	Text Books
1.	Douglas Lambert and James Stock: Strategic Logistic Management
2.	Bowersox: Logistical Management, McGraw Hill Education.
	References
1.	Sahay B S, Supply Chain Management for Global Competitiveness, Macmillan India Ltd., New Delhi.
2	Raghuram G, Rangaraj N, Logistics and Supply Chain Management Cases and Concepts, Macmillan India Ltd., New Delhi, 1999.
3.	John Coyle, Edward Bardi, and John Langley, The Management of Business Logistics, Thomson Learning.

Programme	B. Tech. (Production Engineering)	**Semester -** VIII
Course Code	R4PE4107S	
Course Title	Powder Metallurgy and Ceramics	
Prerequisites	Metallurgy and Materials Technology (R4PE3005S)	

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

1. Select appropriate method of sintering for required applications.
2. Develop correlations between structure and properties.
3. Analyse various Powder production methods and powder metallurgy products and their applications.
4. Differentiate the different characteristics and properties of ceramics.

Syllabus

1. **Introduction**

   Over view of PM method of production of sintered component, applications

2. **Powder production methods and Properties**

   Metal production methods: Atomization, Mechanical (Milling), Electro deposition, Spray drying.

   Powder Treatment- Screening, cleaning, annealing, and lubrication.

3. **Characterization of metal powder**

   Sampling of metal powder, particle size and size distribution. Particle shape analysis, surface area, density and porosity, apparent density, tap density.

4. **Compaction and shaping**

   Compressibility, green strength of compacted metal powder. Dimensional change of sintered metal compacts. Design limitations.

5. **Sintering and consolidation**

   Consolidation of metal powders- Mechanical and physical fundamentals, shape fundamentals.

   Press and tooling, sintering atmosphere, production of sintering atmosphere, roll compaction, PM forging, Hot Iso-static and cold Iso-static pressing.

   Secondary Treatment and Quality Control of PM Materials.

6. **PM Products and their Applications**

   Electrical and magnetic applications (Resistance welding electrode, Metal graphite brushes, Tungsten etc.), PM porous parts, PM Friction materials, Metal bearings, Dispersions strengthened materials, Cutting tool materials- Cemented carbides and tools, cermet.

7.	**Ceramics** Introduction and major applications, Nature and structure of ceramics, types and general characteristics of ceramics- oxide ceramics, carbides, nitrides, silica, glasses, graphite and diamond. General properties and applications- Mechanical Properties, physical properties (density, thermal conductivity, thermal expansion and its anisotropy) Applications in electrical and electronics including high temperature superconductors, frictional ceramics, refractory.
	Text Books
1.	G.S. Upadhaya: Fundamentals of Powder Metallurgy, Cambridge International Science Publishing.
2.	W.B. Jones: Fundamentals Principles of Powder Metallurgy, Edward Arnold Publishing.
	References
1.	Henry Hauser: First Course in Powder Metallurgy, Chemical Publishing Company.
2.	Hausner and M. Mal: Handbook of Powder Metallurgy, Chemical Publishing Company
3.	ASM Handbook: Powder Metals Technologies and Applications, Vol.7, ASM Internationals.
4.	Alan King: Ceramic Technology and Processing, Standard Publishers Distributors.
5.	James S. Reed: Introduction to the Principles of Ceramic Processing, John Wiley.
6.	Randall German: Powder Metallurgy & Particulate Materials Processing, Metal Powder Industry.

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4108S	
Course Title	Additive Manufacturing	
Prerequisites	None	

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

1. Critically sift fundamental principles and workflow for AM of polymers, metals, and composites, and how these principles govern the performance and limitations of each mainstream AM process.
2. Acquire the vocabulary necessary to navigate the complex, multivariate landscape of additive manufacturing equipment, materials, and applications.
3. Acquire the skills necessary to design parts for AM that combine engineering intuition with computationally-driven design and process-specific constraints.
4. Quantitatively assess the value of an additively manufactured part based on its production cost and performance.
5. Evaluate the business case for transitioning a product to be made using AM versus the conventional approach, either in part or in whole.

Syllabus

1.	**Introduction** Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM, Future Directions of AM: Introduction, new types of products and employment and digiproneurship.
2.	**AM process chain** Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build, removal and clean up, post processing
3.	**Classification of AM processes:** Liquid polymer system, discrete particle system, molten material systems, solid sheet system
4.	**Design for AM:** Motivation, DFMA concepts and objectives, AM unique capabilities, exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers, etc.
5.	**Guidelines for process selection**: Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control.

6.	**AM Applications** Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries.
7	**Post processing of AM parts**: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.
	Text Books
1	Chua Chee Kai, Leong Kah Fai, Rapid Prototyping: Principles & Applications, World Scientific.
2	Ian Gibson, David W Rosen, Brent Stucker: Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer.
	References
1.	Ali K. Kamrani, Emand Abouel Nasr: Rapid Prototyping - Theory & Practice, Springer.

Programme	B. Tech (Production Engineering)	**Semester -** VIII
Course Code	R4PE4109S	
Course Title	Finite Element Methods (FEM) for Manufacturing	
Prerequisites	None	

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

1. Understand the basic finite element formulation techniques.
2. Derive element matrix equation by different methods by applying basic laws in mechanics and integration by parts
3. Formulate simple problems into finite elements for application in manufacturing problems in metal cutting and metal forming.
4. Apply and demonstrate use ANSYS/ Comsol, commercial software, to solve basic engineering problems in heat transfer, solid mechanics and fluid mechanics.

Syllabus

1. **Fundamentals**

Initial, boundary and Eigen value problems – weighted residual, Galerkin and Rayleigh Ritz methods - Integration by parts – Basics of variational formulation – Polynomial and Nodal approximation.

2. **One Dimensional Analysis**

Steps in FEM: Discretization. Interpolation, derivation of elements characteristic matrix, shape function, assembly and imposition of boundary conditions-solution and post processing One dimensional analysis in solid mechanics and heat transfer.

3. **Shape Functions and Higher Order Formulations**

Shape functions for one- and two-dimensional elements- Three noded-triangular and four nodded quadrilateral element Global and natural co-ordinate, Nonlinear analysis: Iso-parametric elements, Jacobian matrices and transformations, Basics of two-dimensional, plane stress, plane strain and axi-symmetric analysis

4. **Field Problems**

Steady state problems, Torsional problem, Fluid flow and Heat transfer problems, Acoustic vibrations, Application in manufacturing problems, metal cutting and metal forming. Finite element Solution of structural problems – Two-dimensional elasticity problems – Axisymmetric problem

5.	**Computer Implementation** Pre-processing, mesh generation, elements connecting, boundary conditions, input of material and processing characteristics – Solution and post processing – Overview of application packages – Development of code for one dimensional analysis and validation.
6	**Analysis of Production Processes** FE analysis of metal casting – special considerations, latent heat incorporation, gap element – Time stepping procedures – Crank – Nicholson algorithm – Prediction of grain structure – Basic concepts of plasticity and fracture – Solid and flow formulation – small incremental deformation formulation – Fracture criteria – FE analysis of metal cutting, chip separation criteria, incorporation of strain rate dependency – FE analysis of welding.
	Text Books
1.	Seshu P: Textbook of Finite Element Analysis, PHI Learning Pvt. Ltd.
2.	Reddy J.N: An Introduction to the Finite Element Method, McGraw Hill.
	References
1	Rao S.S: Finite Element Method in Engineering, Pergamon press
2.	T.R. Chandrupatla, A.D. Belegundu, T.Ramesh, and C. Ray: Introduction to finite elements in engineering (Vol. 2). Upper Saddle River, NJ: Prentice Hall.
3.	Lewis R.W. Morgan, K, Thomas, H.R. and Seetharaman, K.N: The Finite Element Method in Heat Transfer Analysis, John Wiley.
4.	Kobayashi, Soo-ik-Oh, and Altan: Metal Forming and Finite Element Methods, Oxford University Press.
5.	David Hutton: Fundamentals of Finite Element Analysis, The McGraw−Hill Companies

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4110S	
Course Title	Product Design and Development	
Prerequisites	None	

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

1. Describe an engineering design and development process
2. Create 3D solid models of mechanical components using CAD software
3. Awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).
4. Ability to coordinate multiple, interdisciplinary tasks in order to achieve a common objective.
5. Reinforcement of specific knowledge from other courses through practice and reflection in an action-oriented setting.

Syllabus

1. **Introduction to product design and development**

   Product life cycle
   Product policy of an organization and profitable product selection
   Product design
   Product design steps and analysis

2. Value Engineering and analysis

   Value Engineering concepts

   Problem Identification

   Functional analysis

   Functional analysis system steps

   Case study on Value Engineering and analysis

3.	Quality Function Deployment Computer Aided Design Robust Design Design for X Ergonomics in product design
4.	DFMA DFMA guidelines Product Design for manual assembly Design guidelines for different processes Rapid prototyping – concepts and advantages Prototyping processes
	References
1.	Ulrich, Karl, and Steven Eppinger. Product Design and Development. McGraw-Hill,
2.	Kemnneth Crow: Concurrent Engg./Integrated Product Development, DRM
3.	Staurt Pugh: Tool Design -Integrated Methods for Successful Product Engineering, Addison Wesley Publishing, New York, NY.

Program Elective 3

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4111S	
Course Title	Sales and Marketing Management	
Prerequisites	Managerial Economics, Finance and Costing (R4PE2009S)	

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

1. Understand the marketing ideas, tools and techniques.
2. Apply basic knowledge of sales and marketing in the business organizations.
3. Evaluate the engineering knowledge for decision making as an owner/entrepreneur.
4. Analyse marketing opportunities and customers focus required in current era.

Syllabus

1.	Definition and function of marketing, understanding marketing, Sales, Company orientations, Journey from sales to marketing, New economy, Environmental forces, Marketing concepts and tools, Approaches to marketing, changing of business practices, Changing of marketing practices, E-business.
2.	Customer value and satisfaction, characteristics of consumer and Organizational markets, Attracting and retaining customers, Cost of lost customer, customer satisfaction, Customer relationship management, Survey of customer needs.
3.	Assessing marketing opportunities, gathering information and measuring marketing demand, Forecasting and demand measurement, Organizational buying decision process, Marketing decision support system, Product life cycle, Portfolio management, New product development, buy grid model.
4.	Competition, Market research, Management strategies, 4Ps of product marketing and 7Ps of service marketing, Product policies, Product brands, Services offering, Pricing, Customer perceived value, Distribution channels, Retailing, Marketing Plan and implementation.
5.	Marketing Organization, Selection of marketing staff, Specialized Training, Role of a salesman, Routine management, Salaries and incentives, Marketing intelligence, market response, Marketing performance, Buyers strengths and negotiation capabilities.
6.	Concept and comparison with consumer buying, Customer focus, Advertising, Sales promotion, Motivation research, Consumer behavior, Buying decision process, Competitive strategies, Audit of customer satisfaction, Improvements through benchmarking, evaluation of consumer society.

	Text Books
1.	Philip T Kotler and Gary Armstrong and Prafulla Agnihotri: Principles of Marketing, Pearson Education.
2.	V. Ramaswamy and S. Namakumari: Marketing Management, McMillan Publishers.
	References
1.	J. Gandhi: Marketing, A Managerial Introduction, TMH.
2.	Mamoria C B and Joshi: Marketing, Kitab Mahal Publication.
3.	R. Srinivasan: Cases studies in Marketing – The Indian Context, PHI Learning.
4.	Belch: Advertising and Promotion: An Integrated Marketing Communications Perspective, McGraw Hill.

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4112S	
Course Title	Energy Management	
Prerequisites	Applied Physics-II (R4PH 1021T), Applied Thermodynamics (R4PE2007T)	

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

1. To be able to explain about the conventional energy resources and their effective utilization.
2. To be able to explain different modern energy conversion technologies.
3. Comprehend the basics of energy auditing with application of different sectors.
4. Demonstrate and understanding of energy management approaches.

Syllabus

1.	**Energy Sources** Introduction, Sources of Energy – Conventional and Non-Conventional, Elasticity of demand and application, concepts to energy, Indian energy scene, Energy storage, Solar energy, water, battery and Mechanical Storage Systems.
2.	**Energy Utilization and Conversion System** Classification of furnaces, controlled atmosphere in furnaces, furnace fuels, efficient use of energy in furnaces, thermal efficiency, reducing heat losses, Combined Power and Heating System, Characteristics of prime movers, Heat and Power requirements, Economics of a CHP System.
3.	**Material and Energy balance** Facility as an energy system, methods for preparing process flow, material and energy balance diagrams, Energy Action Planning Key elements, force field analysis, Energy policy purpose, perspective, contents, formulation, ratification, organizing –location of energy management, top management support, managerial function, roles and responsibilities of energy manager, accountability, motivation, Information system – design barriers, strategies, Marketing and communicating-training and planning.
4.	**Energy Audit** Energy Management information system, thirty-nine steps for energy management, types of energy audit, preliminary energy audits, and Technical assistance in energy audit, energy accounting and analysis, Instruments used in Energy auditing.

5.	**Economics and Finance** Introduction, Economics, Discounted Cash flow, Loans, Investments, Option Identification and Analysis, Optimization, Conflict Correction, Constructing the Optimal Target Investment Schedule, Project Management, Monitoring Against the Target Financial Schedule.
	Text Books
1.	W. Murphy and McKay: Energy Management, Scilab Textbook.
2.	Paul O'Callaghan: Energy Management, McGraw Hill.
	References
1.	Archie Culp: Principles of Energy Conversion, International Student Edition, McGraw Hill.
2.	Kao Chen: Energy Management in illuminating System, CRC Publishers.
3.	R. Raju: Engineering Economics & Engineering Management, Anuradha Agencies.
4.	D. Reay: Industrial Energy Recovery, Wiley Publishers.
5.	T. Boyer: Thermal Energy Recovery, Wiley Publishers.

Programme	B. Tech. (Production Engineering)	**Semester –** VII
Course Code	R4PE4113S	
Course Title	Flexible Manufacturing Systems	
Prerequisites	Mechatronics and Automation (R4PE3009T)	

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

1. Comprehends the concepts of flexible manufacturing systems.
2. Apply the applications of flexible manufacturing systems in industry.
3. Analyze the Model and systems of flexible manufacturing system.
4. Evaluate a FMS model for the required performance.

Syllabus

1.	**Introduction** Limitations with conventional manufacturing, need for FMS, Introduction, Definition, Basic Component of FMS, Significance of FMS, General layout and configuration of FMS, Principal Objectives of FMS, Benefits and limitations of FMS, Area of Application of a FMS in Industry, Various Hardware and Software required for an FMS, CIM Technology, Hierarchy of CIM.
2.	**Group Technology and FMS** Introduction – matrix formulation – mathematical programming formulation – graph formulation – knowledge-based system for group technology – economic justification of FMS- application of possibility distributions in FMS systems justification.
3.	**Computer Control and Software for FMS** Introduction – composition of FMS– hierarchy of computer control –computer control of work center and assembly lines – FMS supervisory computer control – types of software specification and selection – trends.
4.	**FMS Simulation and Data Base** Application of simulation–model of FMS–simulation software – limitation – manufacturing data systems–data flow–FMS database systems–planning for FMS database.
5.	**FMS and Future Factory** FMS application in machining, sheet metal fabrication, prismatic component production – aerospace application – FMS development towards factories of the future – artificial intelligence and expert systems in FMS – design philosophy and characteristics for future.

	Text Books
1.	Jha: Handbook of flexible manufacturing systems, Academic Press Inc.
	References
1.	P. Radhakrishnan and S. Subramanyam: CAD/CAM/CIM, Wiley Eastern Ltd., New Age International Ltd.
2.	Raouf and Ben - Daya: Flexible manufacturing systems: recent developments, Elsevier Science.
3.	Mikell Groover: Automation, production systems and computer integrated manufacturing, Prentice Hall.
4.	Serope Kalpakjian and Steven Schmid: Manufacturing Engineering and Technology, Addison-Wesley Publishing Co.
5.	Taiichi Ohno: Toyota Production System-Beyond Large-Scale Production, Productivity Press (India) Pvt. Ltd.

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4114S	
Course Title	Micro-Electro-Mechanical Systems (MEMS)	
Prerequisites	Machining and Process Engineering (R4PE3003T)	

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

1. Understand the basic Nano-micro concept of manufacturing characterization techniques.
2. Apply concept and procedure to Nano-micro manufacturing methods.
3. Analyze Nano-micro concept of manufacturing problems.
4. Evaluate micro and nano processing methods for various machining systems.

Syllabus

1.	**Scope of Nano Technology** Nano technology Concepts and Applications, Micro- and Nanofabrication, Nano technology in India, Scope for Micro-fabrication, Rise Nano technology Fields, Commercialization Issues of Micro-Nano Technology.
2.	**Micro-fabrication** Mechanical Micromachining, Physical Fabrication Methods, Lithography, Processing Setup, Nano Lithography & Manipulation, Precision Micro- and Nano grinding, Use of Spectrometers & Microscopes.
3.	**Laser-Based Micro and Nanofabrication** Pulsed Water Drop Micromachining, Nano Materials, Synthesis of Nano materials, Bio Materials, Nano Composites, Development of Nano Particles.
4.	**Innovative Applications on Present Devices** Nano chips, Nanotubes and Nanowires, Integration of chips and microprocessors, Technology Support, Meeting Social Needs.
5.	**Ball Milling Technique** Nano powders produced using micro reactors; Nano- crystalline ceramics by mechanical activation; Formation of nanostructured polymers.

6.	**Machining Processes** Micro milling/ micro drilling/ micro grinding processes and the procedure for selecting proper machining parameters with given specifications- EDM micro machining, laser micro/nano-machining- models to simulate micro/ nano-machining processes using molecular dynamics techniques -Wet chemical etching - Dry etching - Thin film and sacrificial processes.
7.	**Nano Design & CAD** Computer Aided Nano Design, VLSI product detailing Finite Element Analysis of Microstructures, 3-D Molecular Modelling.
	References
1.	Mark Jackson: Micro fabrication & Nano manufacturing, Taylor and Francis Group.
2.	ASM: Handbook on machining, Vol 16.
3.	Bharat Bhushan (Ed.): Springer's Hand book of Nano-technology.
4.	W. Fahrner: Nanotechnology and Nano electronics, Springer International.
5.	Hornyak, Tibbals, Dutta, and Moore: Introduction to Nano science and Nanotechnology, CRC Press, Boca Raton.
6.	M. Jackson: Micro fabrication and Nano manufacturing, CRC Press.
7.	P. Raichoudhury: Handbook of Micro lithography, Micro-machining, and Micro-fabrication, Vol. 2, SPIE Press.
8.	Madou: Fundamentals of Micro fabrication, CRC Press.
9.	Timp: Nanotechnology, AIP press, Springer-Verlag, New York.

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4115S	
Course Title	Nano Modeling and Applications: Molecular Dynamic Simulations	
Prerequisites	Machining and Process Engineering (R4PE3003T)	

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

1. Understand the molecular simulation techniques for molecular dynamics and Monte Carlo.
2. Apply the codes and utilize the learned methods towards solving a problem of their interest in Nanotechnology Applications.
3. Analyze the interaction of atom in the systems and their effect
4. Evaluate the problem in Nano science and the Nanotechnology using the molecular stimulation.

Syllabus

1.	**An Overview of Molecular Simulation**: Introduction Molecular Simulations-Computer Experiments and Modelling-Examples of molecular simulations – Monte Carlo-Molecular Dynamics- Newton's equation of motion.
2.	**Interaction potentials**: Degrees of Freedom, Constraints, Lennard Jones Potentials, Short- and Long-Range Potentials, Force Fields, Bonded and Non-Bonded Interactions.
3.	**Statistical Mechanics for Molecular Simulations** Ensembles- Micro canonical Ensemble (NVE), Canonical ensemble (NVT), Isothermal-Isobaric Ensemble, Grand canonical ensemble, Observables-Temperature, Pressure, Thermostats, Barostats-Andersen- Berendsen, Nose-Hoover implementations. Ensembles- Micro canonical Ensemble (NVE), Canonical ensemble (NVT), Isothermal-Isobaric Ensemble, Grand canonical ensemble, Observables-Temperature, Pressure, Thermostats, Barostats - Andersen- Berendsen, Nose-Hoover implementations.
4.	**Monte Carlo Simulations** Monte Carlo (MC) – formulation, MC – structural characterization, MC – applications, Random Number generation- Lattice-Crystal structure, Simple MC Open Source Simulations tools. Unit V Molecular Dynamics Simulations: Molecular dynamics (MD) – formulation, MD – dynamic information, MD – applications, Euler -Verlet algorithms, Analysis trajectories, Correlations functions, Autocorrelations function (ACF), Structure Correlations Function (SCF). MD-Open Source Simulations tools.

	Text Books
1.	D. Frenkel and B. Smit: Understanding Molecular Simulation- From Algorithms to Applications, Academic Press.
2.	J. Haile: Molecular Dynamics Simulation- Elementary Methods, Wiley-Blackwell.
3.	D. Evans and G. Morris: Statistical Mechanics of Nonequilibrium Liquids, Cambridge University Press.
4.	D. Rapaport: The Art of Molecular Dynamics Simulations, Cambridge University Press.

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4116S	
Course Title	Reliability Engineering	
Prerequisites	Applied Probability and Statistics (R4PE2006S), Metrology and Quality Management (R4PE3004T)	

	Course outcomes: On the completion of this course, the learner will able to 1. Apply the concept of Probability to engineering problems. 2. Apply various reliability concepts to calculate different reliability parameters. 3. Estimate the system reliability of simple and complex systems. 4. Carry out a Failure Mode Effect & Criticality analyze.
	Syllabus
1.	Introduction to Reliability and its applications to engineering, discussions on Reliability failure rate, Patters of Failure Distribution and Bathtub curve, Failure data collection and life estimation and Monte Carlo simulation of cumulative probability of failure of consistent components.
2.	Survival probabilities of various systems having subsystems in series, parallel or combined configuration, Assessment of overall reliability by various methods: i) Star Delta, ii) Set theory, iii) Conditional Probability, iv) Matrix Method, v) Event Tree Analysis, Allocation of Reliability through programming and other algorithms, through proper appointment of unreliability, AGREE, ARINC and other methods
3.	Reliability in Engineering Design: Carter's concept of reliability, and Safety Margin in a structural mechanical design, Hazard Analysis through RPN & Graph theory, Through stacking of dimensional tolerance, Reliability Effort Function, Reliability, Availability and Maintainability (RAM), Life Cycle Cost – algorithms, mathematical models & nomograms, Non-Parametric Analysis: Mean and Median Ranking Statistics
4.	Accelerated Method of Reliability Testing-Variable, attribute and K Statistic, Truncated Test, Reliability Centered Maintenance (RCM): Predictive Preventive Maintenance, Diagnostic Techniques used in PPM, Condition Monitoring leading to CBM, HUM
5.	Failure Modes and Effect Analysis (FMEA), Failure Modes Effects and Criticality Analysis (FMECA)
	Text Books
1.	E. Balguruswamy: Reliability Engineering, McGraw Hill Publication.

	References
1.	Dhillon Balbir: Reliability Engineering in Systems Design & Operation, N.Y. Van Nostrand Reinhold.
2.	Charles Smith: Introduction to Reliability in Design, McGraw Hill.
3.	L.S. Srinath: Mechanical Reliability, East West Affiliate (EWA).

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4117S	
Course Title	Design for Manufacturing and Assembly	
Prerequisites	Metal Casting and Welding Technology (R4PE3008T), Metal Forming Technology and Analysis (R4PE3002T), Machining and Process Engineering (R4PE3003T)	

	Course outcomes: On the completion of this course, the learner will able to 1. Provide exposure to a range of current industrial processes and practices used to manufacture products in high and low volumes. Focus in depth on a few selected processes 2. Apply basic principles and criteria for Part Minimization. 3. Quantitative analysis of a design's efficiency**.** 4. Make Critique product designs for ease of assembly.
	Syllabus
1.	**Introduction** History of DFMA, Steps for applying DFMA during product design, Advantages of applying DFMA during product design, Reasons for not implementing DFMA. Manufacturing Process: Classification and capability studies. Materials and material selection: Classification of engineering materials, Material selection for product design.
2.	**Metal Casting:** Appraisal of various casting processes, Selection of casting process, General design considerations for casting — casting tolerances — Use of Solidification Simulation in casting design — Product design rules for sand casting. **Machining Process** Overview of various machining processes — general design rules for machining – Dimensional tolerance and surface roughness — Design for Machining ease — Redesigning of components for machining ease with suitable examples, General design recommendations for machined parts
3.	**Metal forming**: Design factors for forging — Closed die forging design — parting lines of dies — Drop forging die design — General design recommendations Extrusion, Sheet Metal Work: Design guidelines for Extruded sections – Design principles for Punching, Blanking, Bending, Deep Drawing — Keeler Goodman Forming Limit Diagram — Component Design for Blanking.

4.	**Metal Joining** Appraisal of various welding processes, Factors in design of weldments — General design guidelines — pre and post treatment of welds — Effects of thermal stresses in weld joints — Design of brazed joints.
5.	**Design for Assembly** The assembly process, Characteristics and applications, Example of common assembly, Economic significance of assembly, General taxonomies of assembly operation and systems, Assembling a product. Design for Assembly: Introduction, Design consideration, Design for Fasteners: Introduction, Design recommendation for fasteners.
6.	**CAD/CAM Application to Design and Manufacturing**. Geometric Representation in CAD, Extraction of part feature information from CAD Model: Introduction, Feature recognition techniques, Free Form Features, Hybrid Techniques, Reference, Extraction of assembly feature information from CAD Model: Introduction, Assembly features, Definition of assembly feature attributes. Characterization of assembly feature, Examples of Assembly feature, Overview of procedure to extract assembly features from CAD model of Assembly, Description of steps in the assembly feature extraction procedure, Examples of assembly feature extraction: Aircraft wing and automotive chassis assembly.
	Text Books
1.	Geoffrey Boothroyd, Peter Dewhurst and W.A. Knight: Product Design for Manufacture and Assembly, CRC Press.
	References
1.	Kevin Otto and Kristin Wood: Product Design, Pearson Education.
2.	Engineering Design: Dieter, McGraw Hill Publisher
3.	A.K Chitale and R.C Gupta: Product design and Manufacturing, Prentice Hall of India.
4.	Design and Manufacturing – Surender Kumar & Goutham Sutradhar, Oxford & IBH Publishing.

Programme	B. Tech. (Production Engineering)	**Semester** -VIII
Course Code	R4PE4118S	
Course Title	Engineering Optimization	
Prerequisites	Applied Mathematics- II (R4MA1021S), Mathematics for Production Engineers (R4MA2002S)	

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

1. Discuss the rationale behind various types of optimization
2. Formulate the problem as an optimization problem within an appropriate class
3. Derive the optimized solution for the discussed classes
4. Understand the limitations of the techniques

Syllabus

1. **Introduction**

   Historical Development; Engineering applications of Optimization; Art of Modeling, Objective function; Constraints and Constraint surface; Formulation of Design problems as mathematical programming problems, Optimization techniques – classical and advanced techniques

2. **Optimization using calculus**

   Stationary points; Functions of single and two variables; Global Optimum, Convexity and concavity of functions of one and two variables, Optimization of function of one variable and multiple variables; Gradient vectors, Lagrangian function, Hessian matrix formulation, Kuhn-Tucker Conditions

3. **Linear Programming**

   Standard form of linear programming (LP) problem; Graphical method for two variable optimization problem; simplex method, Duality in LP; Primal dual relations; Dual Simplex method, Sensitivity or post optimality analysis

4. **Linear Programming Applications**

   Use of software for solving linear optimization problems using graphical and simplex methods Examples for transportation, assignment, water resources, structural and other optimization problems

5.	**Dynamic Programming** Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP
6.	**Dynamic Programming Applications** Problem formulation and application in Design of continuous beam and Optimal geometric layout of a truss, Water allocation as a sequential process, Capacity expansion and Reservoir operation
7.	**Integer Programming** Integer linear programming; Concept of cutting plane method Mixed integer programming; Solution algorithms; Examples
8.	**Advanced Topics in Optimization** Piecewise linear approximation of a nonlinear function Multi objective optimization – Weighted and constrained methods; Multilevel optimization Direct and indirect search methods Evolutionary algorithms for optimization and search Applications in civil engineering.
	Text Books
1	S.S. Rao: Engineering Optimization: Theory and Practice, New Age International P Ltd., New Delhi.
2	H. A.Taha: Operations Research: An Introduction, McMillan, New York, 1992.
	References
1	G. Hadley: Linear programming, Narosa Publishing House, New Delhi, 1990.
2	K. Deb : Optimization for Engineering Design- Algorithms and Examples, Prentice-Hall of India Pvt. Ltd.
3	K. Srinivasa Raju and D. Nagesh Kumar, Multi-criterion Analysis in Engineering and Management, PHI Learning Pvt.

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Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4119S	
Course Title	Quality Engineering	
Prerequisites	Metrology and Quality Management (R4PE3004T), Applied Probability and Statistics (R4PE2006S)	

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

1. To study basic concept of quality Control and apply various quality control tools and techniques.
2. To study the scientific basis of process capability analysis
3. To study the fundamentals of Acceptance Sampling, its use and economics.
4. Introduction to the Reliability Engineering.

Syllabus

1.	**Introduction** Quality, components of quality control viz; quality of design, quality of conformance, quality assurance, statistical process control, role of QC. in industries
2.	**Basic Probability Concepts** The histogram, Box-and-whisker plot, numerical indices for summarizing data (mean, median, standard deviation, etc.) probability distribution (Normal, Exponential, Poisson, Binomial) concept.
3.	**Statistical Tools for Analyzing Data** Scope of data analysis, statistical inference, sampling variation and sampling distribution, statistical estimation: confidence limits, importance of confidence limits in planning test programs, sample size determination for given accuracy. Hypothesis testing and drawing conclusion, type I and Type II errors, determination of sample size required for testing of hypothesis.
4.	**Control Charts** Control Chart Point of View, System of Chance Causes, Patterns of Variations, Interpretation of Lack of Statistical Control, Interpretation of Patterns of Variation on X & R Charts, Shewart's Normal Bowl, Estimation of Control Limits. Control Charts for Variables, X & R, 6 Charts, O C curve for control charts, Control Charts for Attributes: p, c, np, u- Charts.
5.	**Process Capability Analysis** Objectives Of Analysis, Estimation Of Process Capability, Process Capability Indices, Viz: Cp, Cpk, Cpm, and Their Interpretation.

6.	**Acceptance Sampling** Concept and importance of sampling, economics of sampling inspection, symbols and terms used in relation to sampling plans. Lot-by-lot acceptance using single sampling plan, OC curves, sampling risk, AQL, LTPD, alpha and beta risk, construction of OC curve for given sampling plan, estimating alpha and beta risks for a given plan. Effect of lot size, sample size, acceptance number, producer's and customer's risk. Indexing of acceptance sampling plans by using a single point on OC curve. Average outgoing and the AOQL. Double sampling plans, analysis of double sampling plans, minimizing average total inspection. Use of ANSI/ASQC Z 1.4 standards for attribute sampling plans switching procedure for normal and tightened inspections. Calculation of average sample numbers in double sampling plans. Use of Dodge - Romig sampling plans. Construction of OC curves. Estimation of average inspection, sampling risks, etc. for single and double sampling plans.
7.	**Reliability Engineering** Introduction, Bathtub curve, causes of failure, concepts/definitions of reliability availability, maintainability. Computation of component reliability: failure rate, hazard rate, MTBF, MTTF etc. Reliability of series and parallel systems, redundancy, product/component design analysis using FMECA and fault tree analysis.
	References
1.	J. Juran, and F. Gryna: Quality Planning and Analysis, TMH.
2.	E. Grant and Leavenworth: Statistical Quality Control, TMH.
3.	Amitava Mitra: Fundamentals of Quality Control and Improvement, Pearson Education.
4.	Charles Smith: Introduction to Reliability in Design, McGraw Hill.
5.	L.S. Srinath: Mechanical Reliability, East West Affiliate.
6.	E. Balguruswamy: Reliability Engineering, McGraw Hill Publication.

Programme	B. Tech. (Production Engineering)	**Semester** - VIII
Course Code	R4PE4120S	
Course Title	Product Lifecycle Management	
Prerequisites	Metrology and Quality Management (R4PE3004T), Applied Probability and Statistics (R4PE2006S)	

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

1. Designing products with consideration to business constraints.
2. Understanding the market aspects involved and process involved in bringing new products to the marketplace.
3. Understand the principal issues involved in technical product management throughout all phases of the product life cycle.
4. Be able to develop, plan and manage with a product management plan that covers design, development, test, marketing and sales, and customer support.
5. Be skilled at participating in the development of a strategic plan that relates to organizational objectives for a product or product area including its phase out and replacement at the end of the product life cycle.

Syllabus

1.	**Introduction** Definition, PLM Lifecycle model, Threads of PLM, Need for PLM, Opportunities and benefits of PLM, Views, Components and Phases of PLM, PLM feasibility study, PLM visioning.
2.	**PLM Concepts, Processes and Workflow** Characteristics of PLM, Environment driving PLM, PLM Elements, Drivers of PLM, Conceptualization, Design, Development, Validation, Production, Support of PLM.
3.	**Product Data Management (PDM) Process and Workflow** PDM systems and importance, reason for implementing a PDM system, financial justification of PDM implementation. Versioning, check-in and checkout, views, Metadata, Lifecycle, and workflow. Applied problems and solution on PDM processes and workflow.

4.	**Collaborative Product Development** Engineering vaulting, product reuse, smart parts, engineering change management, Bill of materials and process consistency, Digital mock-up and prototype development, design for environment, virtual testing and validation, marketing collateral
5.	**Developing a PLM strategy and conducting a PLM assessment** Strategy, Impact of strategy, implementing a PLM strategy, PLM initiatives to support corporate objectives. Infrastructure assessment, assessment of current systems and applications.
	References
1.	Michael Grieves: Product Lifecycle Management, McGraw-Hill
2.	Antti Saaksvuori, Anselmilmmonen: Product Life Cycle Management, Springer
3.	John Stark: Product Lifecycle Management: Paradigm for 21st Century Product Realization, Springer-Verlag