

Compulsory Subjects

IC 402 Engineering Management
PR 403 Mechanics of Solids
PR 404 Manufacturing Automation
PR 405 Production Management
PR 406 Manufacturing Technology
PR 407 Design of Machine Elements

Optional Subjects

(Any Three From Any One Group)

Group I Manufacturing Engineering

PR 411 Manufacturing Science
PR 412 Computer Aided Manufacturing
PR 413 Tool & Die Design
PR 414 Design of Machine Tools
PR 415 Inspection & Product Control

Group II Design of Production Systems

PR 421 Facility Planning, Design & Maintenance
PR 422 Project Management
PR 423 Quality Management
PR 424 Operations Research
PR 425 Work Study & Ergonomics

Group III Operations of Production Systems

PR 431 Materials Management
PR 432 Computer Aided Manufacturing
PR 433 Quality Management
PR 434 Operations Research
PR 435 Operations Planning & Control

Engineering Management

Group A

Management and Organisations

Management process: Definition, planning organizing, directing, controlling, coordinating, types of management.

Organisation Definition, planning, design and development, types of organizations.

Management planning and control: Classical, new classical and modern principles. General Management, scientific management, engineering, management, systems management.

Planning: Procedures, resources and constraints, objectives, goals, policies and procedures.

Control: Setting of reference or standards, appraisal or evaluation, monitoring and controlling, types of control.

Human resource planning and management, selection, recruitment, training, retraining, skill development, competence development, promotion and career development, participative management, trade unions, and collective bargaining,

Management of Physical Resources

Plant: site selection procedures, factors affecting selection. Layout-types and relative merits and demerits, Maintenance-Objectives, different types of associated decisions, strategies for effective maintenance, computer applications.

Material : Functions, objectives, planning and control including inventory models with or without storage costs, price break (excluding dynamic and probabilistic considerations). Different classes of inventory. Material Requirement Planning (MRP).

Group B

Financial management: Introduction to standard forms of financial statements, i.e., balance-sheet, profit and loss, and income statement. Fixed and current asset items. Fixed and current liability items. Linkage of two successive balance-sheets through income or profit and loss statement. Funds flow statement. Financial ratios and their implications.

Managerial economics: Concepts, theory of production, marginal productivity and cost. Introduction to theory of firm.

Quality management: Quality definition, quality planning, quality control and quality management, Total quality management, ISO 9000 systems, simple quality control techniques like control charts and acceptance sampling.

Marketing management consumer behavior, market research, product design and development pricing and promotion.

Project management: Introduction. Concept of a project, project management concepts, project simulation, cost or project and means of financing, economic evaluation criteria of the project, project implementation, project planning, scheduling and monitoring, project control (PERT, CPM techniques including crashing). Project evaluation.

Information technology and management. Role of information, management information system and decision support system, Information technology-introduction to e-business, e-commerce and integration tools like enterprise resource planning (ERP).

Mechanics Of Solids

Group A

Review of free body diagrams; Analysis of deformation under axial loading. Simple shear and pressure.

Statically determinate and indeterminate cases. Forces and moments transmitted by simple beams.

Mechanics of deformable solids, stress and strain, transformation of stress and, strain, Mohr circle diagram, equilibrium equations and compatibility conditions.

Material properties and their testing: Elastic, inelastic, plastic and viscoelastic material behaviour. Fatigue and creep. Concepts of ductility, hardness, toughness and their quantification. Tensile and impact tests.

Group B

Stress-strain-temperature relations. Generalised Hooke's law and thermal strains.

Equations of elasticity. Solutions of thin and thick cylinders and rotating disks.

Stresses in beams. Torsion of circular shafts and thin walled sections. Deflection of helical springs.

Yield criteria, energy methods, basic elasticity equations.

Manufacturing Technology

Group A

Introduction. Manufacturing cycle. Manufacturing processes and their selection. Engineering materials and their selection.

Casting: Patterns, gating system design, riser design, product design, defects, inspection techniques. Other casting processes: investment casting, die casting, centrifugal casting and continuous casting. Basic design considerations in casting.

Metal forming: Plastic deformation, hot and cold working. Forming operations-rolling, extrusion, drawing processes, sheet metal operations, load estimations for homogeneous deformation. Sheet metal die design. High velocity forming processes.

Heat treatment processes.

Processing of plastics: Extrusion, injection moulding, blow moulding, rational moulding, thermo-forming and compression moulding. Basic design considerations, rapid prototyping, stereo lithography technique.

Powder metallurgy processing: Production of metal powders, compaction and sintering processes. .

Group B

Metal cutting: Tool materials, tool geometry and nomenclature in ASA, ORS and NRS, cutting fluids, single and multipoint cutting operations, production of gears and screw threads, grinding and finishing processes, specification of grinding wheels.

Machine tools: Primary and secondary drives, guideway and slideways, structure. Introduction to NC, CNC and DNC machining.

New machining methods: Process capabilities and limitations of AJM, USM, WJM, ECM, ECG, EDM, EBM and LBM processes.

Joining processes: Fusion welding processes, heat affected zone, testing of welded joints, solid state welding processes, brazing and soldering. Basic design considerations in welding. Process selection. Adhesive bonding. Mechanical fastening processes.

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Design Of Machine Elements

Group A

Mechanical systems and elements, overall design considerations, safety, ecological and societal considerations in design. Codes for design-Bureau of Indian Standards (BIS)-codes, design data handbook. Load, stress and critical sections in machine parts.

Materials, stress-strain curves of ductile and brittle materials, cast iron, steel, non-ferrous alloys and plastics, hardness and surface properties of materials, material strength, factor of safety and allowable stress. Review of axial, bending, shear and torsional loading on machine components, combined loading, two- and three- dimensional Mohr's circle. Stresses in curved beams, thick and thin shells under pressure.

Deflection and stability, beam deflection and column buckling. Euler's formula and Johnson's formula. Failures theories-maximum normal stress theory, maximum shear stress theory, and maximum distortion energy theory. Application to components made of brittle and ductile materials, stress concentration factor.

Cyclic loading and fatigue failures: Reverse bending, axial and torsion loadings, effect of stress concentration, fatigue life prediction-Miner's rule, effect of surface treatments (shot-peening, surface hardening) on fatigue life of components.

Design of threaded fasteners and power screws, thread forms and threaded fastener types and materials, power screws, bolt tightening and initial tension, static and group of bolts.

Rivets and welding: Loading, bending, direct shear, axial and bending.

Group B

Design of springs: Spring materials, helical compression and extension springs, design for fatigue, loading, leaf springs. Design of sliding bearings, bearing materials, fluid viscosity, hydrodynamic lubrication, Petroff's equation, Raimondi and Boyd chart. Heat dissipation.

Rolling elements bearings: Types, catalogue information (Timken and SKF bearings), bearing life -radial and thrust loads. Selection of bearings. Spur, helical and worm gears, gear tooth profile, gear geometry, module, contact ratio, gear train, gear tooth bending strength, gear tooth surface fatigue analysis, gear material.

Design of shafts, keys, pins and splines, shaft couplings. Cotter and pin joints, pipe joints, gaskets, seal and packing, cylinder joints, flanged joints.

Clutches and brakes: Single and multiple plate clutch, constant wear and constant pressure theories for plate clutches, materials, shoe drum brakes, internal and external shoe brakes.

Power transmission elements: Belts and chain drives, design of flat and V-belts.

Manufacturing Science

Group A

Deformation of metals, stress-strain curves, temperature and strain rate effects, ductility and toughness, plane-strain deformation, mechanism of plastic deformation, control of material properties—alloying and heat treatment.

Sand casting: Pattern materials and allowances, moulding materials, properties of moulding sand, effects of moulding ingredients on mould properties, estimation of pouring time, mechanism of solidification, rate of solidification in an insulating mould, riser design and placement, residual stresses.

Elements of plasticity—yield criteria and flow rule, plastic instability. Analysis of forming processes—forging, rolling, extrusion, wire and strip drawing, using slab method, deep drawing, blanking and piercing. Lubrication and friction in metal forming.

Group B

Metal cutting: Mechanics of orthogonal cutting, chip formation in turning, shaping, planing, milling and drilling, evaluation of surface roughness in machining, heat generation, estimation of average tool temperature, tool wear mechanism and tool life testing, variables affecting tool life machining economics—estimation of cost and optimum cutting conditions.

Metal grinding: Basic mechanics of grinding process, forces and specific energy, grinding temperature—heat sources and estimation of average temperature, wheel wear mechanism, estimation of surface roughness.

Non-conventional machining: Classification of processes, mechanism of material removal and effects of process parameters in AJM, USM, ECM, EDM, LBM, EBM and PAM.

Welding and allied processes: Bonding process in welding, principles of solid-state welding, fusion welding, soldering and brazing, effects of process parameters, metallurgy of welding stress distribution and heat affected zone.

Computer Aided Manufacturing

Group A

Basic definitions of manufacturing systems: Definitions, design, planning and control.

Part design and CAD: Engineering design, design drafting and its interpretation, inspection and measurement. A brief history of CAD, CAD hardware and software. Fundamentals of geometric modeling. CAD data exchange.

Process engineering: Experience-based planning, process capability analysis, basic machining and other manufacturing process calculations, process optimisation.

Hard automation: Introduction to automated manufacturing, fixed automated manufacturing systems, work piece handling hardware for automation and economics of automation.

Programmable logic controllers: Function of controllers, control devices, programmable logic controllers.

Data communication and local area networks in manufacturing: Fundamentals of data communication and local area networks.

Group B

Fundamentals of numerical control: Historical developments and principles of NC, classification of NC, NC part programming, manual and computer-assisted part programming.

Introduction to industrial robots: Power sources, actuators and transducers. Robot applications. Economic considerations of robotic systems.

Group technology: Introduction, coding and classification, benefits of group technology.

Process planning: Introduction, manual process planning, computer aided process planning, variant and generative approaches, simple examples.

Tool And Die Design

Group A

Influence of tools and dies on quality, productivity and environment, tool design methods and procedures, tool making practices, tooling materials and treatment.

Jigs and fixtures. Basic principles of locating and clamping, development of fixture using locating, clamping, indexing tool setting elements, force analysis, standardisation of elements, illustrative examples of machining, welding, assembly and inspection fixtures.

Design of cutting tools and special tools (form cutters and broachers), tooling for CNC, introduction to modular fixtures and tools.

Group B

Die design: Design of sheet metal blanking, piercing, bending and deep drawing dies. Progressive die design.

Mould design. Introduction to die casting and injection mould design. General mould construction. Design of ejection, feed and cooling systems. Parting surface design. Side cores and side cavities. Product design for die casting and injection molding.

Cost estimation and cost benefit analysis.

Design Of Machine Tools

Group A

Conceptualisation of mechanical systems for prescribed scheme; Layout of machine tool elements; Introduction to machine tool drives and mechanisms; General principles of machine tool design.

Design of drive systems; Regulation of speed and feed; Kinematic structure of machine tool gear box; Hydraulic, mechanical and electrical speed regulation.

Design of machine tool structures: Material selection; Welded vs. cast structure; Static and dynamic stiffness; Choice of element sections and their design.

Group B

Analysis of spindles, bearings, slides and guides.

Control systems for machine tools.

Dynamics of machine tools: Machine tools as a closed loop system. Dynamic stability. Forced vibration and chatter in machine tools.

Concept of modular design; Concepts of aesthetic and ergonomics applied to machine tools; Acceptance tests and standardisation of machine tools.

Manufacturing Automations

Group A

Definition of automation, reasons for automating, pros and cons of automation.

Fundamentals of manufacturing and automation: Manufacturing operations and automation strategies, production economics.

High volume production systems: Detroit type automation, analysis of automated flow lines, assembly and line balancing, automated assembly systems.

Numerical control production systems: CNC, DNC and adaptive control.

Group B

Industrial robots: Robotics technology, robot applications.

Material handling and storage: Automated materials handling, automated storage and retrieval systems.

Flexible manufacturing systems (FMS): FMS workstations, material handling and storage systems, computer control systems, planning the FMS, analysis methods for FMS, applications and benefits.

Automated inspection and testing: Inspection and testing, statistical quality control, automated inspection principles and methods, sensor technologies for automated inspection, coordinate measuring machines, other contact inspection methods, machine vision and other optical inspection methods, and non-contact inspection methods.

Production Management

Group A

Introduction. Concept of management, concept of a system, production system, production functions.

Organisation fundamentals. Guidelines for good practice, organisation structures, organisation charts, span of control, number of levels, number of executives, management functions.

Production economics: Kinds of costs, evaluation of capital investments. Capital budgeting, break-even analysis, make or buy decisions, evaluation of alternatives, discounted cash flow, equivalent comparison methods, depreciation.

Aggregate planning. Planning time horizons, inputs to aggregate planning systems, single and multistage aggregate planning systems, decision processes for aggregate planning—graphical method, linear decision rule, and linear programming method-Demand management. Time span for forecasts, forecasting system, forecasting methods-time series, casual and predictive forecasting methods, selection of a forecasting method.

Group B

Scheduling. Scheduling process scheduling for a multistage production system, sequencing production operations, Johnson's rule.

Facilities management. Plant location—factors influencing plant location, cost factors, plant location decision process, selection of a location for new facilities, evaluation of alternative regions and sub-regions. Plant layout-objectives, decision process, types of layouts, comparison of layouts. Line balancing and sequence analysis concepts. Materials handling-devices for materials handling, basic considerations in the selection of materials handling system.

Human factor engineering: Methods analysis and works measurement, methods study, process analysis, operation process chart, operator process chart, motion study, principles of motion economy, motion analysis. Time study-types of studies, procedure for job time study, physical environment.

Quality management: Three aspects of quality, functional responsibility for quality in a manufacturing system, economics of quality assurance, quality control, QC decision variables, process control, control charts, acceptance sampling, single, double and sequential sampling plans, concept of total quality control (TQC).

Maintenance management: Maintenance functions, concept of reliability engineering, reliability improvement, preventive maintenance, preventive maintenance policy, repair policy, replacement decisions, queuing theory and its applications in maintenance.

Introduction to PERT/CPM.

Inspection And Product Control

Group A

Introduction: Functions and responsibilities of inspection and product control department, organisation personnel—job specifications and inspection training Programme.

Product and component specifications: Purpose, types of specifications, drawing up specifications, specifying tolerances, designations of critical dimensions, tolerance build ups in assembly, revision of specifications.

Inspection planning: Establishing the acceptable quality level, control charts, process capability.

Measurements and gauging: Nature of measurements, sensitivity and precision of measurements, limit gauging, gauge types and their use, Taylor's principle, wear allowance, gauge makers allowance, guidelines for the selection of fits, ISO system of limits and fits.

Dimensional measurements: Linear measurements, principles of selection and operation of linear measuring instruments. Comparators, interferometers, use of lasers in measurements.

Group B

Angular and profile measurements: Measurement of taper, calibration of circular dimensions, optical instruments for angular measurements, auto collimator, measurements of screws and gears.

Measurement of surface roughness: Surface properties, methods of surface finish measurement and analysis, roundness assessment, surface roughness measuring machines; operation and selection principles.

Measuring machines: Principles of automated and in-process inspection, mechanical, hydraulic, optical, electromagnetic, and electronic devices. General principles of selection and operation of measuring machines, co-ordinate measuring machines (CMM).

Non-destructive testing and inspection: Introduction, scope of applications. Methods of non-destructive testing and their selection, magnetic particle inspection, X-ray examination, Gamma radiography, ultrasonic inspection of flaws in manufactured parts, electric method, damping test, non-magnetic methods.

Interchangeability and selective assembly—their role in mass production.

Facility Planning, Design And Maintenance

Group A

Introduction. Facility planning, design functions and scope.

Facility location. The supply distribution system, location strategy, nature of location decision, location evaluation methods, single or multiple facility locations, choice of a site within a region, network location problems.

Design of plant or facilities. Factors in the design of ant or facilities, materials handling and facility design layout.

Facility layout. Introduction, planning the layout, advantages of a good layout, analysis of a layout problems, patterns of flow, activity relationship chart-from-to-chart, layout procedures, Nadler's ideal systems approach, Immer's basic steps, Apple's plant layout procedure, systematic layout, planning, flow and activity analysis. Types of layouts—fixed position layout. Product layout-line balancing methods, process layout, layout of work areas, group technology based layouts, layout problem and the assignment model.

Group B

Applications: General layout problems in storage, receiving and warehousing. Facility services and non-manufacturing applications, computerised layout planning and evaluation (CRAFT and CORELAP), policy for location and layout of storage system.

Maintenance of facilities and equipment: Maintenance policies, data collection and analysis, periodic maintenance, total preventive maintenance, the maintenance unit, duties and planning for the routine maintenance Programme, maintenance in operation, repair and replacement.

Project Management

Group A

Introduction. Elements of project management, feasibility analysis, detailed evaluation of projects, analysis of technical feasibility, measurement of cost and benefit, cost/benefit analysis.

Planning and scheduling networks. Arrow diagram, dummy activities, activity-on-node diagram, Fulkerson's numbering algorithm, finding the critical path.

Critical path analysis. Job slack, early start and early finish times, late start and late finish times, total and free slack, project due date and earliest completion time, scheduling from a network, time costing methods-examples and applications. Lowest cost schedule.

Group B

The PERT model. Introduction, PERT's event orientation, PERT assumptions. The problem of uncertainty, expected times, variability of activity times, expected length of critical path, probability of project completion by a given due date, PERT/cost. A network cost accounting system.

Network scheduling with limited resources. Heuristic methods for resource scheduling, resource levelling program, resource allocation program.

Modifications and extensions of network models. Precedence network and algorithms, effect of job splitting, decision networks, introduction to probabilistic networks.

Quality Management

Group A

Introduction. Historical background, quality assurance, total quality assurance system, training and documentation, quality movement in India.

Standardisation for quality. Standards for quality, standards and quality objectives, quality levels and quality grading, national system of standardisation, ISO quality system and international certification.

Quality management. Management tools, affinity diagram, relation diagram, tree diagram, matrix diagram, arrow diagram, matrix-data analysis. Total Quality Management.

Quality circles. Introduction, quality circle operation, steps to sustain quality circle activities.

Quality audit. Purpose and requirements of audit, audit methods, guidelines for system audit.

Control charts and process capabilities. Theory of control charts, control charts for variables, process capabilities and specification, control charts for attributes, various types of control charts and their applications.

Group B

Sampling inspection. Inspection of attributes, aim of a sampling method, acceptance sampling. OC curves, single and multiple sampling plans and methods, sequential sampling, average outgoing quality, comparison of OC and average outgoing quality approaches.

Process design and improvements. Need for planned experimentation, planning for experiments, response surface methods, standard experimental designs, concurrent design, Taguchi method, tolerance design.

Reliability engineering. Quality and reliability, achieving reliability, redundancy, reliability prediction, fault tree analysis, worst case analysis, step stress testing, failure modes, effects and criticality analysis, life characteristics, design reviews.

Operations Research

Group A

Introduction: Origin and nature of operations research, impact of OR on industrial decision making.

Linear optimization models: Problem formulation and solution procedures, simplex method, tabular form of simplex method, transportation and assignment problems, applications, duality and sensitivity-Network models; Shortest route algorithm, critical path scheduling.

Theory of games: Competing situation. Two-person zero-sum games.

Group B

Dynamic optimization models: Principle of optimality, application examples.

Integer programming: Solution techniques (cutting plane algorithm), application examples.

Introduction to non-linear programming. Optimization with non-linear objective function with and without constraints (simple examples).

Queuing models. Taxonomy of queuing models, finite and infinite queues, single server model with Poisson input and exponential service. Applications.

Neural networks: Fundamentals, scope of application, different types/categories.

Work Study & Ergonomics

Group A

Introduction. Scope of motion and time study, productivity and work-study.

Method study. Various tools used in method analysis, recording techniques, charts and symbols, operation process chart, flow process chart, two-hand process chart, multiple activity chart.

Motion economy. Rules for motion economy (related to use of body, arrangement of work place, tools and equipment, etc.).

Method development. Tools, work simplification Programme.

Micro motion study. Fundamental hand motions. micro motion study equipment, simo chart and memo-motion study.

Work measurement. Concept and theory of Work measurement.

Time study. Timing of work elements, error in time study, operation sheets.

Work sampling. Theory of work sampling, determination of standard time.

Group B

Standard time. Performance rating systems, objective rating, rating of skill and effort, synthetic rating, rating factor and allowances, computation of standard times, examples and applications.

Predetermined motion time systems. Motion time measurement (MTM), development of MTM, application methodology, simplified MTM.

Work factor. Work factor system, principle and variables, introduction of work factor, comparison with elemental time standards.

Job evaluation and merit rating. Job evaluation methods, selection of evaluation plan, job rating, merit rating—types and methods.

Wages and incentives. Real and money wages, incentive types, incentive plans, incentives for indirect labour, operating cost of incentive schemes.

Ergonomics. Introduction and scope, human abilities, human factor considerations, machine systems, measurement of human performance, design considerations for man-machine systems, ergonomics and work study.

Materials Management

Group A

Introduction. Importance of materials management, definition and scope.

Corporate policy and materials management. General corporate policy, concept of MBO, make or buy, quality and quantity requirements, cost aspects.

Organisation and control. Materials management in overall organisation, organising materials management, special requirements, interdepartmental relationships, materials research.

Materials planning and budgeting. Importance, techniques and guidelines, budgeting, ABC analysis, codification and standardisation, source selection.

Purchasing management. Creative purchasing, purchase systems, price forecasting, buying seasonal commodities, purchasing under uncertainty, purchase of capital equipment, international purchasing, import substitution, public buying, legal aspects of buying, buyer seller relationships.

Warehousing and stores management. Location and layout of stores, stores management, system and procedures, incoming materials control, stores accounting and stock verification, scrap management, value engineering, materials handling and transportation.

Group B

Inventor)' management. Relevant inventory related costs, economic ordering quantity, static risk model, dynamic-certain model, cost sensitivity analysis, practical inventory systems, system design, safety stock. Q-system, P-system, optional replenishment system.

PERT and OR techniques in materials management, application of computers in integrated materials management systems, materials requirement planning.

Value engineering: Origin, applications and impact.

Evaluation of materials management functions. Organisation, process and criteria. Index ratios.

Computer Aided Engineering Design

Group A

Computer aided design of engineering systems. Applications in modelling, analysis, design and manufacturing.

Computer graphics, raster graphics and interactiveness, pixels and graphic display in computers, windows and view-ports, lines and circles, graphic data storage and manipulation, hardware display, input and output devices.

Geometric transformations—two, three-dimensional and homogeneous transformations, rotation, translation, mirror, perspective, projections, etc.

Computer aided drafting. Introduction to Auto CAD—use of menus and icons, two-dimensional drawings using auto CAD lines, circles, tangents, simple machine drawings, dimensioning, blocks and layers, editing and adding text to a drawing.

Advanced auto CAD—three-dimensional drawings. Curves, surfaces and solid models, customizing. Auto CAD, auto LISP.

Group B

Design of curves—PC, Bezier and B-spline curves, normal, tangent, curvature and torsion of curves. Blending of two curves.

Design of surfaces, tangent and normal planes. Curvature and twist, surface patches—PC, Bezier and B-spline, ruled and developable surfaces, swept and revolved surfaces.

Solid modeling—wire frame, constructive solid geometry (CSG) and boundary representation (B-rep); parametric instancing. Cell decomposition, spatial occupancy enumeration, generalized sweep.

Mass property calculations—curve length, surface area, volume, centroid, mass, moment, etc.

Finite element analysis: Fundamentals of finite element analysis; discretization, mesh generation, pre and post processing and simple applications.

Operations Planning & Control

Group A

Introduction. Operations and operations manager, manufacturing and service operations, production/ operations functions and the organisation.

Analysis for operations management. Production/ operations strategy, guides to creating POM strategy and utilities, trade-off analysis, models in operations management. Break-even and investment analysis.

System planning and design for operations. Long range planning and system design, operational planning and control, marketing considerations in the design of operations, interface with personnel, finance and engineering, forecasting and long range planning.

Forecasting methods. Forecasts based on subjective opinion, index and averages, statistical methods, moving average and trend forecaster, exponential smoothing, evaluating and controlling the forecasts, information requirements and forecasting.

Intermediate range planning and scheduling. Introduction, planning horizon, aggregate planning, rules for aggregate planning, production smoothing, rolling schedules, backlogging demand, plan development— graphical method, plans with varying production rates, developing alternative plans, aggregate planning by linear programming.

Group B

Inventory control: Introduction, independent and dependent demand, inventory replenishment policies, the economic order quantity (EOQ), adapting EOQ to fit the real situation, safety stocks.

Production scheduling and job shop control. Economic production quantity, lot sizing, scheduling with limited capacity, facility cycle scheduling method, capacitated lot-size heuristics, planning the use of several productive units, Gantt charts and scheduling, despatching and information flow in job shops—examples.

Multistage production systems: Planning in multistage systems, capacity planning, materials requirement planning, master scheduling and MRP-II, JIT production systems.

Supply chain management: Introduction, relevance. Simple models.

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