Contents of Courses for the M. Engg. Programme in Industrial and Manufacturing Engineering

ME 503 Computer Aided Design (CAD)

Fundamentals of CAD: Introduction, the design process, application of computers for design, creating the manufacturing data base, benefits of CAD. Computers, input / output devices, storing an image. Geometric Modeling: Geometric Modeling Techniques: multiple-view two dimensional input, wire frame geometry, surface models, Geometric Entities: points lines, surfaces, solids, tesselated modeling, Cubic Curves: Hermite curves, Bezier curves, B-spline curves, Bicubic Surfaces: Hermite surfaces, Bezier surfaces, B-spline surfaces. Solid Modelers: solid modeling construction technique: pure primitive instancing (PPI), spatial occupancy enumeration (SOE), cell decomposition (CD), sweeping (S), constructive solid geometry (CSG), boundary representation (BREP), Euler formula , solid modeler storage data bases, feature recognition, feature-based design using CSG construction, using a BREP for part interpretation; data transfer standards. computer graphics: Computer Graphics and the Part Model: Interactive graphics, graphics in CAD, two-dimensional graphics, two-dimensional transformations, three-dimensional graphics, three-dimensional transformations, composite transformations in three dimensions, projections, realistic image generation. Concurrent Engineering: Key definitions; driving forces behind concurrent engineering; the meaning of concurrent engineering; schemes for concurrent engineering: axiomatic design, DFM guideline, design science, design for assembly, the Taguchi method for robust design, manufacturing process design rules, computer-aided DFM, group technology. Failure mode and effects analysis, summary of concurrent engineering tools.

ME 504 Finite Element Analysis

FEA of One-Dimensional Problems: Introduction, basic steps in FEA; modeling, discretization, connectivity of elements, imposition of boundary conditions, solutions & post processing; applications to heat transfer, fluid mechanics, & solid mechanics problems. Bending of Beams: Euler-Bernoulli beam element, governing equations, application of FE on beam, beam examples, plane truss element, frame element, Timoshenko beam & frame element, inclusion of constraint equations. Finite Element Error Analysis: Approximation errors, various measures of errors, convergence of solutions, accuracy of solutions. Numerical Integration & Computer Implementation: Isoparameteric formulations, numerical integrations, natural coordinates, computer implementation (pre-processor, processor, post-processor). FEA of Two-Dimensional Problems: Introduction, single variable problems; boundary value problems; model equations, discretization, weak form, finite element model, assembly, solutions & post processing; mesh generation; imposition of boundary conditions; applications; parabolic equations; hyperbolic equations. Interpolating Functions, Numerical Integration & Modeling Considerations: Interpolating techniques; triangular, rectangular, & serendipity elements; coordinate transformation; integration on a master element; modeling, mesh generation, load representation. Plane Elasticity: Assumptions of plane elasticity; basic equations, weak formulations; principle of virtual displacement in matrix form; finite element model, matrix & weak form model; evaluation of integrals. Bending of Elastic Plates: Classical plate model; finite element model; shear deformable plate model; displacement field, virtual work statement;

shear locking & reduced integration; introduction to time dependent problems; computer illustrative examples.

ME 511 Materials Science

Polymeric Material: High performance fiber, high performance elastomers, high performance coatings, special polymers, moderately high polymers, engineering polymers. Materials development and modification, multilayer and adhesive technology will also be part of this course. Physical and chemical testing of polymers. Fundamentals of Polymers: Molecular structure, polymerization processes, morphology of polymer molecules, plasticisers and fillers. Composition and characteristics of principal types of polymers, convention constant rate of elongation test, creep tests, isochronous curves and other forms of data presentation, strain recovery and stress relaxation, anisotropy of properties time-dependence of strength and creep rupture, durability under cyclic loading BS impact tests. Fracture of Polymers: Fundamentals of fracture mechanics, application of fracture mechanics to polymers, KC determinations, KC crack speed curves instability, environmental effects impact testing, application to practical problems. Composites: Composite materials compared with conventional materials, fiber and matrices, composite mechanics, elastic properties, failure processes, failure at notches, notch sensitivity and fracture energy. Fatigue and failure of composite materials. Deterioration of properties owing to environmental conditions, hybrid composite materials, manufacturing the by hand lay-up, preparing specimen for mechanical testing, burn off tests to determine fiber volume fracture. Categories of Composites. Properties of glass and other fibers. Matrix materials composites as monotropic membranes. Mathematical models of stiffness of composites based on mechanics of materials and energy considerations. Elasticity of anisotropic materials. Strength of composites. Outline of methods of manufacturing composites and of their applications.

ME 521 Automation & Controls

Production Operations & Automation Strategies: Automation defined; types of automation; reasons for automation; manufacturing industries; types of production; functions in manufacturing; organization & information processing in manufacturing; plant layout; production concepts & mathematical models; automation strategies. Automotive Type Automation: Automated flow lines; methods of work part transport; transfer mechanism; buffer storage; control functions; automation for machining operations; design & fabrication considerations; general terminology & analysis; analysis of transfer lines without storage; partial automation; automated flow lines with storage buffers; computer simulation of automated flow lines. Assembly Systems & Line Balancing: The assembly process; assembly systems; manual assembly lines; the line balancing problem; methods of line balancing; computerized line balancing methods; flexible manual assembly lines; types of automated assembly systems; parts feeding devices; analysis of multi-station assembly machines; analysis of a single station assembly machine. Computer Assisted Optimal Control: Structural model of a manufacturing process; steady state optimal control; adaptive control; on line search strategies.

ME 522 Computer Aided Manufacturing (CAM)

Conventional Numerical control: Introduction, basic components of an NC system, the NC procedure, NC coordinate systems, NC motion control systems, applications of numerical control, economics and justification. NC Part Programming: Punched tape in NC, tape coding and format, manual part programming, computer assisted part programming, the APT language, NC programming with interactive graphics, voice NC programming, manual data input, APT word definitions. Computer Controls in NC: Problems with conventional NC, NC controller technology, computer numerical control, direct numerical control, adaptive control machining systems, trends and new developments in NC. Group Technology and FMS: The role of group technology in CAD / CAM integration; methods for developing part families; classification and coding: hierarchical code, attribute code, hybrid code, selecting a coding system, development your own coding system; coding systems: OPITZ coding system, MICLASS coding systems; facility design using group technology; cell design; economic modeling in a group technology environment: production planning cost model, group tooling economic analysis; economics of group technology: benefits in design, benefits in manufacturing, benefits to management, group technology advantages / disadvantages summarized. Introduction to FMS, FMS workstations, materials handling and storage system, computer control system, planning the FMS, analysis methods for FMS, application and benefits. Process Planning: The role of process planning in CAD / CAM integration, Approaches to process planning: Manual approach, Variant approach, Generative approach; Process planning systems: CAM-I automated process planning (CAPP), DCLASS, Computer Managed process planning (CMPP), Machinability data system.

ME 523 Operations Research

Linear Programming: Formulation, graphic solution, assumptions of LP, The simplex method, equality constraints, inequality constraints, negative RHS, duality theory, primal and dual problems. Special Types of LP Problems: The transportation problem, production scheduling, North-west corner rule, Vogel's approximation method, Russell's method, transshipment problem, assignment problem, goal programming, sensitivity analysis, parametric programming, dynamic programming, integer programming. Queuing Theory: Basic queuing process, the birth and death process, basic model with infinite and finite queue, limited input source, priority queuing model. Inventory Control Theory: Deterministic models: continuous review-uniform demand, shortages permitted, quantity discount- shortages not permitted. Stochastic Models: Single- period model with no setup cost, model with initial stock level, single- period model with setup cost, two- period inventory model with no setup cost.

ME 524 Reliability & Quality Engineering

Reliability Measures: The reliability function; expected life; failure rate and hazard function; reliability and hazard function for well known distributions such as exponentional; normal, log normal, Weibull, and gamma distributions; hazard models and product life; constant hazard function, linearly increasing hazard function, piecewise linear bathtub hazard function, power function model, exponential model. Static Reliability Model: Series system, parallel system, series & parallel combinations, complex system analysis, reliability considerations in design. Reliability Engineering Design: Reliability design methodology, strength and stress distributions, safety factors and reliability, reliability bounds in probablistic design.

Transformation of random variables. Sums and differences of normal random variables, error analysis, statistical tolerancing. Interference Theory and Reliability Computations: General expression for reliability; reliability computations for normally, log normally, exponentionally, Gamma and Weibully distributed stress and strength; reliability design examples. Reliability in Design and Testing: Dynamic reliability models, reliability estimation, sequential life testing, Bayesian reliability in design and testing, reliability optimization. Control Charts: Properties of the distribution of sample means, sample range estimation of standard deviation, chance and assignable causes, control charts for mean & range, control charts for mean & standard deviation, control charts for proportion defective & defects per assembly. Tests of significance to compute confidence limits. Acceptance Sampling: Introduction, OC curve, consumer & producer risks, AQL & LTPD, Acceptance Sampling for continuous production, Acceptance by Variables, Single, Double, & Sequential Sampling. Quality, Reliability, & Maintainability: Definitions, management of quality control, economic aspects of quality decisions, capability & variability analysis, various aspects of life testing, reliability, & maintainability, Introduction to ISO 9000, and ISO 14000.

ME 525 Advanced Manufacturing Processes

Mechanics of Orthogonal & Oblique Metal Cutting: Chip formation; thin-zone and thick-zone models for analysis; prediction of forces. Rake angle in oblique cutting; shear angle; velocity relationships; force and stress relationships; shear angle and chip flow direction measurement; strain and strain rate. Temperatures in Metal Cutting, Cutting Fluids and Surface Finish: Heat generation in metal cutting; effect of cutting speed on temperatures; measurement of cutting temperatures; cutting fluids: effects of cutting fluids; assessment of cutting fluid cooling effectiveness; fluid film lubrication; boundary lubrication; characteristics of an efficient lubricant; selection of cutting fluids; theoretical roughness in turning, drilling, milling, & grinding; measurement of roughness; average values of roughness for various manufacturing processes. Tool Life & Tool Wear: Application of wear theories to tool wear; adhesion, abrasion, & diffusion wear; forms of wear in metal cutting; crater wear, & flank wear; variables affecting tool life; Taylor's tool life equation; generalized tool life equation; methods of tool life testing data. Economics of Metal Cutting: Application of minimum cost per piece, maximum production rate, and maximum profit rate criteria in turning, milling, drilling, and shaping operations. Non Traditional Machining Processes: Principle of EDM, operation of tool feed, tool wear and tool materials, dielectric fluid, nature of machined surfaces, metal removal, accuracy, wire cut (EDM), principle of ECM, electrolyte, metal removal rate, nature of machined surface, efficient of tool feed and supply voltage on accuracy, tool shape correction, electrochemical grinding, chemical milling, ultrasonic machining, laser beam machining, electron beam machining, electrochemical deburring, abrasive jet machining, plasma arc machining.

ME 526 Advanced Metal Forming

Macroscopic Plasticity & Yield Criteria: Tresca, & Von Mises criterion; plastic work; effective stress; effective strain; flow rules for plastic stress-strain relations; principle of normality. Work Hardening & Plastic Instability: Tensile test; mechanical properties; nominal & true stress-strain curves; work hardening expression; behavior after necking; direct compression; bulge test; plane-strain compression test. General approach to instability; balanced biaxial tension; thin-

walled sphere internal pressure; significance of instability. Strain Rate & Temperature: Strain rate; Superplasticity; combined stress and strain-rate effects; strain rate dependence; temperature dependence of flow stress; hot working; temperature rise during deformation. Ideal Work: Ideal work or uniform energy; extrusion & rod drawing; friction; redundant work, and mechanical efficiency; maximum drawing reduction. Slab Analysis: Sheet drawing; comparison of slab method & ideal work method; wire drawing; direct compression in plane strain; average pressure during plane-strain compression; sticking friction; axisymmetric compression; flat rolling. Bending: Springback in sheet bending; bending with superimposed tension; sheet bendability; bending of sheets & tubes; forming limits in shape bending. Cupping, redrawing, and ironing cup drawing; effects of work hardening; deformation efficiency; effects of tooling; redrawing; ironing. Complex Stamping: Localized necking in biaxial stretching; formability; forming limit diagrams; cupping tests; edge cracking; bulk forming tests.

ME 527 Human Factor Engineering

Introduction: Scope of ergonomics, human operator as system components; physical size and shape dynamics, Anthropometry, sources and application of energy input sensitivity, central processing capacity, input characteristics, environmental effects, heat and vibration, lightning and noise. Techniques in human factor studies; the assessment of physical activity, subjective assessment technique, methods of work analysis. Design Requirements: Interface design; space requirements and layout visual presentation of information, auditing presentation of information, machine dynamics, control design, environmental factors, jobs aids, System evaluation.

ME 528 Computers Integrated Manufacture

Fundamentals of CIM: Definition of CIM, technology issues: the one-model concept, configuration management, data base management systems, network, distributed data base systems, management of technology, other emerging issues; fundamentals of networking: network concepts, OSI / MAP / TOP. Integrative Manufacturing Planning & Control: Overview of manufacturing engineering; overview of production control: forecasting; master production schedule; rough-cut capacity planning; material requirements planning; capacity planning; order release; shop-floor control; quality assurance; manufacturing planning and control systems, cellular manufacturing: overview; hierarchical manufacturing control model, JIT manufacturing philosophy.

ME 529 Management Information Systems (MIS)

Management Information System Concepts: What a System is, Information System Defined, Computer Based Information System, Functions of an Information System, Manager and information needs, the role of managers, management levels and information needs. Types of Information Systems: Transaction processing systems, management information systems, decision support systems, executive support systems. The System Development Life Cycle: Reasons to develop new information systems, system analysis, problem definition, requirements analysis, project justification, system analysis tools, system design, logical design stage, system design tools, prototyping and its effects on the system development life cycle, automating system analysis and design, system implementation, testing and installation stage, training stage, and system maintenance. File and Database Processing: File processing, file management systems, database processing, database management systems, database models: the hierarchical model, the

network model, the relational model, object-oriented model, database design considerations. Managing database: distributed databases, knowledge-based systems. Expert system shells, knowledge engineering, uses of knowledge-based systems.

EM 504 Project Management Framework and Tools

Role of projects in organization's competitive strategy; Standard methodologies for managing projects; project life cycle; design-implementation interface; estimating: preliminary and detailed; contractual risk allocation; scheduling: PBS; WBS; integration of scope, time, resource and cost dimensions of a project; evaluation of labor, material, equipment, and subcontract resources; scheduling techniques including CPM/ PERT, GERT, critical chain; solving real-world project schedules; Monte Carlo simulation; cost budgeting; cost baseline; cash flow analysis; earned value analysis; cost control; proposal presentation; application of software for project management (MS Project, Primavera Project Planner-P3).

IM 527 Intelligent Manufacturing Systems

Intelligent Manufacturing Systems; Architecture, basic building blocks, knowledge modeling and representation; rule based and fuzzy logic systems, artificial neural networks; perception model, network architectures, pattern recognition and machine vision, learning methodologies; back propagation algorithm; genetic algorithms, techniques for intelligent shop floor control, flexible manufacturing systems, intelligent process monitoring and control using PLCs, integration of robots in intelligent manufacturing systems.

TE 505 Advanced Statistics

Probability Distributions & Transformation of Variables: Uniform, binomial, hyper geometric, poisson. Normal, exponential, chi-square, F, & T distributions; random sampling; sampling distribution of mean; central limit theorem. Statistical Inference & Hypothesis Testing: Confidence & significance level; sample size determination; point & interval estimates; interval estimates for population mean, population standard deviation, & population proportion. Type I, & Type II errors; one tail & two tail tests; tests concerning means & variances. Linear & Multiple Linear Regression & Correlation: Simple linear regression; properties of least square estimates; confidence limits & tests of significance; choice of a regression model; correlation. Estimating the coefficients; adequacy of the model. Analysis of Variance: One way classification; tests for the equality of several variances; single degree of freedom comparisons; multiple range test; comparing treatment with a control; comparing a set of treatments in blocks; randomized complete block design; random effects model. Factorial Experiments: Two-factor experiments; interaction in two-factor experiments; two-factor analysis of variance; three-factor analysis; choice of sample size. 2K Factorial Experiments: Yate's technique for computing contrasts; factorial experiments in incomplete blocks; fractional factorial experiments; analysis of fractional factorial experiments.

MS 552 Applied Mathematics-II

Analysis of Variance: One way classification; Tests for the equality of several variances; single degree of freedom comparisons; multiple range test; comparing treatment with a control; comparing a set of treatments in blocks; randomized complete block design; random effects

model. Factorial Experiments: Two-factor experiments; Interaction in two-factor experiments; two-factor analysis of variance; three-factor analysis; choice of sample size. 2K Factorial Experiments: Yate's technique for computing contrasts; factorial experiments in incomplete blocks; fractional factorial experiments; analysis of fractional factorial experiments.

MS 553 Computer Applications

Hardware: Basic structure of a digital computer; CPU; types of memory; input/output section; data representation; binary numbering system; peripheral devices. Software: Computer programming languages; machine language; high level languages; operating systems; virtual storage; time sharing; distributed processing. Role of Computers in Engineering: Applications of computers in engineering problems including design and simulation. Use of computer aided engineering software & mathematical modeling. Hierarchy of computers; Local area networks; manufacturing automation protocol; management information system; manufacturing data base; functions of a manufacturing organization; hierarchical computer control concept.

IM 505 Automated Manufacturing Systems

Automated flow lines; Methods of work part transport; Transfer mechanism; Buffer storage; Control functions; Automation for machining operations; Design and fabrication considerations; General terminology and analysis; Analysis of transfer lines without storage; Partial automation; Automated flow lines with storage buffers; Computer simulation of automated flow lines. The assembly process; Assembly systems; Manual assembly lines; The line balancing problem; Methods of line balancing; Computerized line balancing methods; Flexible manual assembly lines; Types of automated assembly systems; Parts feeding devices; Analysis of multi-station assembly machines; Analysis of a single station assembly machine. Schemes for Concurrent Engineering: Axiomatic Design, DFM Guidelines, Design for Assembly, The Taguchi Method for Robust Design, Manufacturing Process Design Rules, Computer-Aided DFM, Group Technology; Failure-Mode and Effects Analysis. Robot motions, Robot drive power, Types of robots; Robot motions: Link geometries, Frame of reference, Orientation, Changing frames of reference, Workspace Descriptions; Robot accuracy and repeatability; Economic justification of Robots; Characteristics of robot applications; Robot Cell design; Types of robot applications, Material handling applications; Processing applications; Assembly & inspection.

IM 506 Business Process Reengineering

Fundamentals of process management; importance of process decisions and process choices; strategic process decisions for manufacturing and service environments. Costs, quality, and timeliness as the primary attributes of value; creation of value through strategies and processes.
Process improvement tools and frameworks; process maps, value stream mapping, service blueprinting, reengineering, Poka-Yoke, lean systems and six-sigma. Simulation and modeling of discrete event systems and processes; random numbers generation, Monte-Carlo simulation, and probability distributions for discrete event processes. Implementing BPR methodology; initiating organizational change; building the reengineering organization; identifying BPR opportunities, understanding existing processes, reengineering processes, blueprinting new business systems, performing transformation.

IM 513 Six Sigma Methodologies

Introduction to Six Sigma, Internal & External Customers, DMAIC (Define, Measure, Analyze, Improve, Control) cycle, six sigma goals and metrics, six sigma training, six sigma teams, green; black and master black belt, design for six sigma, DMADV (Define, Measure, Analyze, Design, Verify), case studies.

IM 515 Agile and Lean Manufacturing

Introduction to Lean Manufacturing, value concept, lean objectives & tools, origins of lean systems, group technology, 5S, single minute exchange of dies, total productive maintenance, Kaizen, Just-In-Time Manufacturing Systems, Push & Pull Manufacturing Systems, Poka-Yoke, Toyota production system, introduction to agile manufacturing, research projects in agile manufacturing, design of market responsive supply and distributions manufacturing systems.

IM 525 Design for Manufacturing

Concepts of design for manufacturing (DFM), role of DFM in product specification and standardization, design, development, and functional requirements, material and process selection. Introduction to components of DFM – design for assembly, performance, quality, bio-compatibility, ergonomics, recycling, etc. Design to Cost. Quantitative methods of material selection in DFM based on engineering properties, material performance indices, comparative property charts, costs, etc., Evaluation of single and multi-attribute utilities. Design rules for selection of materials and processes, Part geometry and tolerances, shape factor, prototyping, computer-aided material and functional modeling, mathematical optimization, formation of objective and constraint functions, factorial analysis. Case studies on product design for manufacturing and assembly.

IM 526 Facilities Planning and Layout

Introduction to Product and Process Design, process planning and sequencing; manufacturing processes: automation with respect to sensing equipment and control systems; manufacturing systems: fixed and flexible manufacturing systems, single-stage multi-machines systems, Just in time and group technology approach; requirements and selection of machines and labour, building, organization, communications and support requirements; material handling principles: equipment and its selection criteria, flow lines, grouping, packaging, storage and warehousing, plant and office layout: conventional approaches, flow space and activity relationships, computerized layout planning models and algorithms, computer aided process planning, operation sequence and path planning with constraints, case studies in CAPP, simultaneous development of plant layout and material handling systems, basic facility location problems, single- and multiple facility placement problems, heuristics and computerized approaches.