Detailed Syllabi for the M.Tech. Programme in

MANUFACTURING TECHNOLOGY

FIRST SEMESTER

MAG604 MATHEMATICAL METHODS

L	T	P	C
3	1	0	3

Module I: Linear Algebra (10 hours)
Vector spaces, Basis, Dimension, Inner product spaces, Gram-Schmidth Process, Linear Transformations, Range and Kernel, Isomorphism, Matrix of transformations and Change of Basis.

Module II: Series Solutions of ODE and Sturm-Liouville Theory (9 hours)
Power series solutions about ordinary point, Legendre equation and Legendre polynomials, Solutions about singular points; The method of Frobenius, Bessel equation and Bessel Functions. Sturm-Liouville problem and Generalized Fourier series.

Module III: Partial Differential Equations (10 hours)
First order PDEs, Linear equations, Lagrange method, Cauchy method, Charpits method, Jacobi method. Second order PDEs, Classifications, Formulation and method of solutions of Wave equation, Heat equation and Laplace equation.

Module IV: Tensor Calculus (10 hours)
Line, area and volume integrals, Spaces of N-dimensions, coordinate transformations, covariant and mixed tensors , fundamental operation with tensors, the line element and metric tensor, conjugate tensor, Christoffel's symbols , covariant derivative.

References:

1. D. C. Lay: Linear Algebra and its Applications, Addision Wesley, 2003.
2. F. G. Florey: Elementary Linear Algebra with Application, Prentice Englewood, 1979.
3. K. Hoffman and R. Kunze: Linear Algebra P. H. I., 1971.
4. W. W. Bell: Special Functions for Scientist's and Engineers, Dover Publications, 2004.
5. Sokolnikoff and Redheffer – Mathematics of Physics and Engineering. 2nd edition. McGraw Hill, 1967.
6. Ian Sneddon, Elements of Partial Differential Equations, McGraw Hill International, 1985.
7. Tychonov & Samarski: Partial Differntial Equations of Mathematical Physics, Holden-Day, San Francisco , 1964.
8. B. Spain: Tensor Calculus, Oliver and Boyd, 1965.
9. J. Irving and N. Mullineux: Mathematics in Physics and Engineering, Academic Press, 1959.
10. Shepley L Ross,Differential Equations, JohnWiley&Sons, Third Edition, 2004.
11. L.A.Pipes and L.R. Harwill: Applied Mathematics for Engineers and Physicists, Mc Graw Hill, 1971.
12. M.A. Akivis and V.V Goldberg, An Introduction to Linear Algebra and Tensors, Dover Publications,1997.

*** L: Lecture; T: Tutorial; P: Practical; C: Credits**

MEC601 ADVANCED MACHINING SCIENCE

L	T	P	C
3	1	0	3

MODULE I (8 hours)

Mechanics of metal cutting; tool geometry-effect of rake, lead and clearance angles; shear angle and its relevance, strain and strain rate in orthogonal cutting, stress distribution along rake face, theories of Merchant's, Lee and Shaffer's, Oxley's, etc.

MODULE II (11 hours)

Inserts-chip groove geometries; nomenclature, selection and applications in turning, milling, drilling, design concepts; In cut optimization, selection of operating conditions. carbide grade design, carbide coatings, ceramic, super hard grade design, effect of cutting variables on forces, tool failure analysis, theories of tool wear, measurement of tool wear, tool life and economics of machining, CNC machining.

MODULE III (8 hours)

Thermal aspects in machining; heat and temperature distribution, modeling of chip formation in metal cutting, modeling of machining characteristics in turning, milling, drilling, grinding, etc., measurement of cutting forces and cutting temperatures.

MODULE IV (12 hours)

Micro machining; micro-turning, micro-milling, micro-drilling, micro EDM, micro-WEDM, micro ECM, etc., ultra-precision machining, electrolytic in-process dressing and grinding, high speed machining, nano surface generation, ductile cutting of silicon wafers, mechanism of ductile cutting, nanometric cutting, chip formation, recent developments.

References:

1. E. J. A. Armarego, R. H. Brown, "The Machining of Metals", Prentice Hall Inc.
2. Kronenberg, "Machining Science and Applications", Pergamon Press.
3. Geoffrey Boothroyd and W. A. Knight, "Fundamentals of Machining and Machine Tools", Marcel Dekkel Inc.
4. J. A. McGeough, " Advanced Methods of Machining", Chapman and Hall.
5. P. L. B. Oxley, "The Mechanics of Machining,", Ellis Horwood Ltd.
6. E.M. Trent, "Metal Cutting", Butterworth Heinemann.
7. Gary F. Benedict, "Nontraditional Manufacturing Processes", Marcel Dekker Inc.
8. Amitabha Battacharyya, "Metal Cutting, Theory and Practice", New Central Book Agency
9. Amitabh Ghosh and Asok Kumar Mallik, "Manufacturing Science", Affiliated East West Press Pvt. Ltd.
10. B. L. Juneja and G.S. Sekhon, "Fundamentals of Metal Cutting and Machine Tools", New Age, International (P) Ltd.
11. V. C. Vekatesh and H. Chandrasekharan, "Experimental Techniques in Metal cutting", Practice Hall of India Pvt. Ltd.
12. M. C. Shaw, "Metal Cutting Principles", CBs Publishers.
13. Serope Kalpakjian and Steven R. Schmid, "Manufacturing Engineering and Technology, Pearson Education.

MEC602: METAL FORMING

L	T	P	C
3	1	0	3

MODULE 1 (10 Hrs) :

Review of Theory of Elasticity**,** Stress tensor, stress transformations, principal stresses, differential equations of equilibrium, spherical and deviatoric stress tensors, octahedral stresses, infinitesimal and affine transformation for deformation, rotation and strain tensors, strain transformations, principal strains, spherical and deviator strain tensors, octahedral strains, finite deformations, Mohr's circles for state of stress and state of strain, generalized Hooke's law, Hooke's law for isotropic and homogeneous materials, plane stress and plane strain.

MODULE II (10 Hrs) :

Introduction to the Theory of Plasticity**,** Stress space, yield criterion for metals, von Mises yield criterion, Tresca's yield criterion, representation of the above in stress space, yield surface, experimental investigations, subsequent yield surfaces, representation of loading and unloading in stress space.

Basic considerations of plasticity theory, simple models of material behavior, Levy-Mises and Prandtl-Reuss stress strain relations, experimental investigations, plastic potential theory and plastic work, maximum work hypothesis, Drucker's stability postulates, isotropic and kinematic hardening, plastic instability.

MOUDLE III (10 Hrs) :

Metal Forming Processes and Analyses**,** Processes, Study of drawing, extrusion, rolling, forging bending and HERF processes with classifications.

Analyses: drawing and extruding through frictionless dies – wire and strip, drawing and extruding of cylindrical bodies, drawing and extruding of strip and tube through tapered dies in conditions of plane strain, deep drawing, drawing through dies of circular contour, rolling of sheet in conditions of plane strain, plane strain forging, bending.

MODULE IV (9 Hrs) :

Slip Line Field Theory**,** Incompressible two-dimensional flow, slip lines, equilibrium equations (referred to slip lines), Henkey's theorems, hodograph, simplest slip line fields, application in forming processes – extrusion and forging.

Bound theorems , lower bound and upper bound theorems with proof.

References:

1. Durelli, Phillip's & Tsao: Introduction to the theory of theoretical and Experimental analysis of stress & strain - McGraw Hill Book Co., 1958
2. Tumoshinko and Goodier : Theory of Elasticity - McGraw Hill, Book Co.
3. Johnson & Mellur : Engineering Plasticity – Van Nostrand – Reinhold Co.
4. Hoffman O and Sachs G : Introduction to the theory of Plasticity - Metal Forming applications – McGraw Hill Book Co.
5. Mendelson : Introduction to Theory of Plasticity

MEC603 ADVANCED METROLOGY AND COMPUTER AIDED INSPECTION

L	T	P	C
3	1	0	3

Module I (8 hours)

Experimental Test Plan: Random Tests, Replication & repetition
Uncertainty analysis: Type A and Type B, Determining combined standard uncertainty- Uncorrelated and correlated input quantities, reporting, conformity.

Module II (10 hours)

Surface Roughness Measurement: Stylus instruments, other techniques, Data acquisition and filtering, Amplitude parameters, Texture parameters, Surfaces in three dimensions.
Form Evaluation: Instruments, Parameters, Algorithms

Module III (12 hours)

Coordinate Measuring Machines: Construction, Operation & Programming, probing systems, probe and stylus, non contact sensors, probe calibration, error compensation of co-ordinate measuring machines, algorithms and sampling methods used in data analysis, thermal and environmental effects, compensation of probing errors. CMM Software, scanning, reverse engineering applications, performance evaluation of co-ordinate measuring machines.

Module IV (9 hours)

Latest Developments: Machine Vision: Sensing, Preprocessing, Segmentation, Description, Recognition and Interpretation, Laser interferometry, Nanometrology

References:

1. ISO, "Guide to the expression of Uncertainty in Measurement", 1995.
2. Figliola, Richard S, & Beasley, Donald E, "Theory and Design for Mechanical Measurements", Third edition, John Wiley & Sons Inc,
3. Tom R Thomas, "Rough Surfaces 2nd ed", Imperial College Press, London, 1999.
4. John A Bosch : Co-ordinate Measuring Machines and Systems – Marcel Dekker, Inc. 1995
5. S.Fu, R.C.Gonzalez, C.S.G.Lee, Robotics: Control, Sensing, Vision, and Intelligence, Chapters 7,8, pages 296-449

MEC691 MANUFACTURING TECHNOLOGY LAB

L	T	P	C
0	0	3	2

Exercises on cylindrical and centreless grinding, measurements in Universal Measuring Microscope, Profile Projector, and with various advanced instruments, parametric studies in Electro Discharge Machining, flatness measurement using autocollimator, metallographic studies using Metallurgical Microscope, measurement of tool angles and studies of tool wear in inserts using Tool Maker's Microscope, Experimental evaluation of cutting forces using dynamometers, studies and experiments on Micro Machining Center, programming and measurements with CNC Coordinate Measuring Machine, surface texture analysis, experiments on non destructive evaluation using ultrasonic testers, exercises on virtual instrumentation.

MEC692 SEMINAR I

L	T	P	C
0	0	3	1

Each student shall prepare a paper on any topic of interest in the field of specialization – Manufacturing Technology. He/she shall get the paper approved by the Programme Coordinator/Faculty Advisor/Faculty Members in the concerned area of specialization and present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

SECOND SEMESTER

MEC611 INDUSTRIAL AUTOMATION AND ROBOTICS

L	T	P	C
3	1	0	3

Module I (9 hours)
Introduction to automation-Definition, types, merits and Criticism-Manufacturing plants and operations-automation strategies-Basic elements of automated system- Advanced Automation functions-Levels of automation.

Module II (10 hours)
Industrial control Systems-Process, Discrete manufacturing industries-Continuous and Discrete Control systems-an overview of Computer process control-Fundamentals of automated Assembly system. Group technology-Part families, Part Classification and coding-Production Flow Analysis.

Module III (10 hours)
Introduction to Robotics-Robotics System-Classification of Robots-Robot Characteristics-Kinematics for manipulator-Frames and Transformations-Forward and inverse Kinematics-DH representation-Derivation of forward and Inverse kinematic equations for various types of Robots- Applications of Robots.

Module IV (10 hours)
Introduction to manipulator Jacobian- Tool Jacobian- Velocity Propagation from link to link-Static forces in manipulators-Jacobian in Force domain-Introduction to dynamic analysis-Lagrangian formulation-Trajectory planning-Joint space and Cartesian space.

References:

1. John J Craig, **Introduction to Robotics, Mechanics and control,** second Edition Addison – Wesley, 1999.
2. Saeed B Niku**, Introduction to Robotics, Analysis, Systems and applications**. Prentice Hall India-2002.
3. Groover, Mikell.P Automation, Production systems and Computer integrated Manufacturing –Prentice hall India-2004.
4 Mark W Spong & M Vidyasagar, **Robot Dynamics and Control,** John Wiley & Sons, 1989
5 K S Fu R C Gonzales, C S G Lee: **Robotics Control, Sensing, Vision and Intelligence,** McGraw Hill 1987
6 R P Paul : **Robot Manipulators Mathematics Programming, Control,** The computer control of robotic manipulators, The MIT Press 1979
7 Robert J Schilling: **Fundamentals of Robotics, Analysis and Control.** Printice Hall of India 1996
8 R.K.Mittal and I.J.Nagarath: **Robotics and Control,** TMH-2003
9 Groover,Mikel.P,CAD/CAM-Computer Aided Design and manufacturing-PHI-2000.
10 Shinsky-Process control System-PHI-2000.

MEC612 QUALITY ENGINEERING AND MANAGEMENT

L	T	P	C
3	1	0	3

MODULE I (10 hrs)

Quality and quality assessment – concept of Total Quality Management - Total Quality pioneers – Deming's philosophy – Juran's contributions – Crossby's contributions – quality and competitiveness – leadership concepts – Total Quality tools – customer satisfaction and translating need into requirements – employee involvement – continuous process improvement – customer-supplier partnership – quality cost concept – quality management – quality systems – ISO 9000 certification.

MODULE II (10 hrs)

Quality Function Deployment - House of Quality – adding other factors to the House of Quality. Bench marking – approaches to benchmarking.
Product design – reliability goals – system reliability – design for safety – design for manufacturability – error proofing – failure mode and effect analysis – FMEA documentation. Quality circles , motivation theories. Taguchi's quality engineering – concept of loss function – robust design. Concept of Total Productive Maintenance.

MODULE III (9 hrs)

Statistical Process Control – control charts for variables – process capability – control charts for attributes – special control charts – process control and quality improvement – pursuit of decreased process variability.

MODULE IV (10 hrs)

Sampling plans and quality assurance – acceptance sampling – economics of inspection – operating characteristic curve – parameters affecting acceptance sampling plans – types of sampling plans - characteristics of a good sampling plan – acceptance quality level – Dodge-Romig sampling tables – ATI and AFI – acceptance sampling by variables – selection of proper sampling procedures.

References:

1. D.H.Besterfield et al : **Total Quality Management**, Pearson Education Asia, 2001
2. J M.Juran and F.M.Gryna : **Quality Planning and Analysis**, Tata McGraw Hill (3rd Edition), 1995
3. B.L.Geoetsch and S.B.Davis: **Introduction to Total Quality : Quality Management for Production, Processing and Services** (2nd Edition) Prentice Hall, 1997
4. Bharat Wakhlu: **Total Quality**, Wheeler Publishing, 1998
5. Taguchi G, Elsayed E.A, and Hsiang T.C: **Quality Engineering in Production Systems**, McGraw-Hill Book Company, International Edition, 1989.
6. E.L.Grant and R.S.Leavenworth : **Statistical Quality Control** (7th Edition), McGraw-Hill International Edition.

MEC613: MACHINE TOOL DESIGN AND COMPUTER NUMERICAL CONTROL

L	T	P	C
3	1	0	3

Module1(8 hrs)

Machine tool as a closed loop system, design principles of metal cutting machine tools, machine Kinematics, criteria for selection of operating capacity and design parameters, analysis of formative motions and preparation of layouts, concepts of standardization, design of elements for strength, rigidity and life.

Module1I (12 hrs)

Design of speed box and feed box. stepped and step-less regulation of speed and feed .Ray diagram, Layout of spindle drive and feed drive in machine tools, thread cutting mechanism, machine tool structures, design of bed, head stock, guide-ways- design of spindle and power screws, structural analysis.

Module1II (8 hrs)

Machine tool dynamics – free and forced vibrations, review of multiple degree of freedom system, response to excitations, modes of vibration, self-excited vibration, effect of chip thickness variation, stability analysis, regenerative chatter.

Module1V (11 hrs)

Types of CNC machine tools, machining centers, 5 axis machining, Design of CNC machine tools, Mechatronic elements, sensors and transducers, tool changers, testing of machine tools, positioning accuracy and repeatability. Measurements, Laser interferometry, machine tool error analysis, sources of error, error compensation strategies, real time error compensation techniques, CNC programming, industrial design, aesthetics and ergonomics.

Reference:

1. J. N. Acherkan, Machine tool design, Vols. 1 to 4, MIR Publishers, 1982.
2. J. F. Blackburn, G. Reetholf, J. L. Shearer, Fluid power control
3. G. Shleisinger, Testing of Machine tools, Pergamon press, 1982.
4. Leonard Meirovitch, Elements of Vibration analysis, MCGraw Hill, 1986.
5. N. K. Mehta, Machine Tool Design and Numerical Control, 2nd edition, Tata McGraw Hill Publishing Company, 1996.
6. P. Radhakrishnan, etal CAD/CAM/CIM 2nd editions, New age international Publishing, 2000.
7. Boothroyd, Fundamentals of Metal Machining and Machine Tools, McGraw Hill Book company.

MEE624 METAL CASTING AND JOINING

L	T	P	C
3	1	0	3

Module I (8 hours)

Foundry – Sand casting – Pattern layouts – Parting lines – Mould and Core making – Heat transfer between metal and mould – Solidification of casting – Freezing of pure metal – Homogeneous and Heterogeneous nucleation – Crystal growth – Freezing of alloys.

Module II (11 hours)

Design of gating system – Theoretical consideration – Directional solidification – Design of risers – Modulus – Caine's and shape factor methods – Use of CAD in the design of gating and risering – Application of chills.

Special Moulding processes – Shell moulding – Investment casting – Die casting – Centrifugal casting – High Pressure moulding – Casting defects and their remedies – Fettling and testing of casting.

Module III (10 hours)

Metal Joining – Classification – Welding power sources – Arc and Arc characteristics – Behaviour of arc with variation in current and voltage – Welding electrodes – ISI specifications for electrodes – Electrode selection – Newer welding processes such as Plasma arc, Laser beam, Electroslag, and Ultrasonic welding, Joining by brazing, Soldering and Adhesive bonding

Module IV (10 hours)

Welding Metallurgy – Heat flow in welding – Metallurgical transformation in and around weldment – Implication of cooling rates – Heat affected zone (HAZ) – Weldability of plain carbon steels, Stainless steels, Cast iron, Aluminium and its alloys. Design of weldments – Joint design – Residual stresses and distortion – Testing of welded joints – Destructive Tests and Non-destructive tests (NDT)

References:

1. Heine, Loper & Rosenthal, Principles of Metal Casting, TMH Publications.
2. P. C. Mukherjee, Fundamentals of Metal Casting technology, Oxford & I. B. H Publications.
3. Jail P. L, Principles of Foundry Technology, T M H Publications.
4. Welding for Engineers – Udin, Funk & Wulf, John Wiley and Sons.
5. ASM Metals Hand Book.
6. J. L. Morris, Welding Process and Procedures.

MEC693 CAD/CAM LAB

L	T	P	C
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Manual and computer assisted part programming, exercises on CNC Turning Centre, CNC Machining Centre. Solid modeling exercises on advanced Softwares like 'I-DEAS' 'Pro-Engineer', 'CATIA'. CNC part programming exercises on Pro-Engineer, CATIA, I-DEAS, MasterCAM, ESPRIT, PREDATOR, etc. Exercises on finite element analysis using ANSYS and ABAQUS software. Modeling and fabricating components using RP Machine, Programming exercises on Robots and CIM system. Pneumatic circuit design and implementation using pneumatic simulator. PLC programming and testing.

MEC694 SEMINAR II

L	T	P	C
0	0	3	1

Each student shall prepare a paper on any topic of interest in the field of specialization – Manufacturing Technology. He/she shall get the paper approved by the Programme Coordinator/Faculty Advisor/Faculty Members in the concerned area of specialization and present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

THIRD & FOURTH SEMESTERS

MEC795 COMPREHENSIVE VIVA

L	T	P	C
0	0	0	1

Each student is required to appear for the Comprehensive Viva-Voce examination. This is an oral examination based on the courses (Theory, Laboratory and Seminar) undergone by the student in the first and second semester M. Tech. Programme.

MEC796 PROJECT

L	T	P	C
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The project work starts in the third semester and extends to the end of the fourth semester. The student will be encouraged to fix the area of work and conduct the literature review during the second semester itself. The topic shall be research and development oriented. The project can be carried out at the institute or in an industry/research organization. Students desirous of carrying out project in industry or other organization have to fulfill the requirements as specified in the "Ordinances and Regulations for M. Tech. under the section - Project Work in Industry or Other Organization."

At the end of the third semester, the students' thesis work shall be assessed by a committee and graded as specified in the "Ordinances and Regulations for M. Tech.". If the work has been graded as unsatisfactory, the committee may recommend a suitable period by which the project will have to be extended beyond the fourth semester.

At the end of the fourth semester, the student shall present his/her thesis work before an evaluation committee, which will evaluate the work and decide whether the student may be allowed to submit the thesis or whether he/she needs to carry out additional work.

The final viva-voce examination will be conducted as per the "Ordinances and Regulations for M. Tech."

ELECTIVES:

MEC621 MECHATRONICS

L	T	P	C
3	1	0	3

Module I (9 Hours)

Introduction To Mechatronics System: Key elements-Mechatronics Design Process-Types of Design-Traditional and Mechatronics Designs-Advanced Approaches in Mechatronics-Real Time Interfacing –Elements of Data Acquisition System.

Module II (10Hours)

Actuators, Sensors&Transducers: Fluid Power and Electrical Actuators-Piezoelectric Actuator; Sensors for position, motion, force and temperature-Flow sensors-Range sensors-Ultrasonic sensors-Fibre Optic Sensors-Magnetostrictive transducer-Selection of Sensors.

Module III (10Hours)

Signals, System & Controllers: Introduction to Signals, system and Controls-System representation-Linearisation-Time Delays-Measures of System performance; Closed loop Controllers-PID Controller, Digital Controllers-Controller tuning, adaptive Control-Introduction to Microprocessors, Micro-controllers and Programmable Logic Controllers-Components-PLC programming.

Module IV (10 hours)

Advanced Applications In Mechatronics: Sensors for Condition Monitoring-Mechatronics Control in Automated Manufacturing-Artificial Intelligence in Mechatronics-Fuzzy Logic Application in Mechatronics-Microsensors in Mechatronics-Case Studies of Mechatronics Systems.

References:

1. BOLTON, W, Mechatronics, Pearson education Asia 2004.
2. Devadas Shetty, Richard A Kolk, Mechatronics System Design, Thomson Learning, 2001
3. Dan Necsulescu Mechatronics, Parson education Asia 2002.
4. HMT Ltd, Mechatronics, TMH 1998.
5. B.P.singh, Microprocessors and Microcontrollers, Galgotia Pub First Edn, 1997
6. Frank D.Petruzella, Programmable Logic Controllers, TMH, 1989
7. Krishna Kant, Computer Based Industrial Control, PHI, 1999.

MEC622 COMPUTER GRAPHICS

L	T	P	C
3	1	0	3

MODULE I (10 Hrs.)

Introduction to computer graphics-Overview of computer graphics, Representing and interacting with pictures, Description of graphic devices, Raster Scan Graphics, Line drawing algorithm, Circle generation, Fundamentals of initializing.

MODULE II (10 Hrs.)

Two Dimensional Transformations, Three- dimensional transformations – scaling, shearing, rotation, reflection, translation. Affine and perspective geometry – Orthographic, axonometric and oblique projections; perspective transformations.

MODULE III (9 Hrs.)

Plane curves, non-parametric and parametric curves ; Space curves – Representation of space curves, cubic spline, parabolic blending, Bezier curve, B-spline curves, NURBS.

MODULE IV (10 Hrs.)

Surface description and generation – Surface of revolution, Sweep Surfaces, Linear coon surfaces, Bezier surfaces, B-Spline surface, B-Spline surface filling, Introduction to solid modeling, Hidden Lines and Hidden Surfaces.

As part of the sessional requirement, computer program oriented term projects and term papers are essential

References:

1. David F Rogers & J H Adams, **Mathematical Elements of Computer Graphics,** 2nd Edition; McGraw Hill International Editions 1990
2. David F Rogers, **Procedural Elements for Computer Graphics**, McGraw Hill International Editions, 1995.
3. Donald Hearn & M Pauline Baker, **Computer Graphics**; Second Edition, Prentice Hall of India Private Limited, 1995
4. Foley, Van Dam Feiner & Hughes, **Computer Graphics Principles and Practice,** Second Edition, Addison – Wesley Publishing Company, 1997
5. Michael E Mortenson, **Geometric Modeling**, John Wiley & Sons, 1985

MEC623 SIX SIGMA

L	T	P	C
3	1	0	3

MODULE I (9 hrs)

Six Sigma Basics – Overview & Implementation, Define phase, Measure phase, Process Flow Charting/Process Mapping, Basic Tools, Probability, Overview of Distributions and Statistical Process, Probability and Hazard Plotting, Six Sigma Measurements, Basic Control Charts, Process Capability and Process Performance Metrics, Measurement Systems Analysis.

MODULE II (10 hrs)

Six Sigma Analysis Phase – Visualization of Data, Confidence Intervals and Hypothesis Tests, Inferences : Continuous Response, Inference : Attribute (Pass/Fail) Response, Comparison Tests : Continuous Response, Comparison Tests : Attribute (Pass/Fail) Response, Bootstrapping, Variance Components, Correlation and Simple Linear Regression, Single – Factor (One – Way) Analysis of Variance (ANOVA) and Analysis of Means (ANOM), Two-Factor (Two-Way) Analysis of Variance, Multiple Regression Logistic Regression, and Indicator Variables.

MODULE III (10 hrs)

Six Sigma Improve Phase – Benefiting from Design of Experiments (DOE) Understanding the Creation of Full and Fractional Factorial 2K DOEs, planning 2K DOEs Design and Analysis of 2K DOEs, Other DOE Considerations, Robust DOE, Response Surface Methodology.

Six Sigma Control Phase – Short – Run and Target Control Charts, Control Charting Alternatives, Exponentially Weighted Moving Average (EWMA) and Engineering Process Control (EPC), Pre-Control Charts, Control, Plan, Poka-Yoke, Realistic Tolerancing, and Project Completion.

MODULE IV (10 hrs)

Lean Six Sigma – Leand and its Integration with Six Sigma process, Integrating of Theory of Constraints.

Design for Six Sigma – Manufacturing applications, Service/Transactional Applications, FSS Overview and Tools, Product DFSS, Process DFSS.

Management of Six Sigma – Change Management, Project Management and Financial Analysis, Team Effectiveness, Creativity

References :

1. Breyfogle, Forrest, Implementing : Six Sigma : Smarter Solutions Using Statistical Methods, New York – John Wiley & Sons, 1999
2. Harry, Mikel and Rich Schroeder, Six Sigma : **The Breakthrough Management Stategy Revolutionizing the World's Top Corporations,** New York – Doubleday, 2000.
3. Montgomery, Douglas C : **Introduction to Statistical Quality Control** 4th ed., New York – Joh Wiley & Sons, Inc. 2001

MEC624 MODERN MACHINING PROCESSES

L	T	P	C
3	1	0	3

Module 1 (8 hrs)

Introduction to advanced machining processes – classification of unconventional machining process – physical parameters of the processes – shape application and work materials – Process capability – Process economy.

Module I1 (12 hrs)

Electrical Discharge Machining – Mechanism of metal removal – spark erosion generators - Electrode feed control – Analysis of relaxation and R-L-C type circuits – material removal rate – critical resistance. Process parameters – selection of electrode material and dielectric fluid – Machining accuracy and finish ,wire EDM.. Electrochemical machining – Fundamental principles of ECM – Metal removal rate – power source, MRR for alloys – Electrode feed rate – Dynamics of ECM process – tool profile correction - Modifications on basic ECM process.

Module 1II (11 hrs)

Ultrasonic machining – Elements of process – Principle of operation – process parameters – Tool feed mechanism – analysis of metal removal rate. Abrasive jet Machining, Principle, process parameters, Plasma Arc Machining – Mechanism of metal removal – process parameters – Types of torches, Electron beam machining – set-up for the machining – process capabilities, Laser beam Machining – Principle – Material removal – Thermal analysis.

Module 1V (8 hrs)

Comparative evaluation of different unconventional machining process – Principle of operation of chemical machining, Ion beam machining, Modified conventional machining, hot machining – Principle of restricted contact cutting, high production cutting tools for turning and drilling, deep hole drilling, SPDT.

References:

1. Debarr & Oliver – Electrochemical machining – American Elsevier Publishing Company, Inc.
2. Bhattacharya, A., New Technology – The institution of Engineers (India).
3. Krasyuk, Electro-spark machining of metal, consultants bureau, New York.
4. P. C. Pandy & Shan, Modern machining processes – Tata McGraw Hill Publishing Company, New Delhi.
5. S. A. Bhattacharya, Metal cutting Theory and Practice, Central Book Publishers, Calcutta.
6. Ghosh and Mallick – Manufacturing Science – Affiliated East-West Press Pvt. Ltd., New Delhi.
7. Vijay K. Jain Advanced Machining Process, Allied Publishing Pvt. Ltd., 2002.
8. P. K. Mishra, Non-conventional machining – Narosa Publishing House – 1997.

MEC625 FINITE ELEMENT METHOD AND APPLICATIONS

L	T	P	C
3	1	0	3

MODULE 1 (10 Hrs.)

Introduction – Basic concepts – steps involved in finite element analysis – Variational methods of approximation – Galerkin's method – shape functions – Family of elements – Assembly and solution techniques – One dimensional problems.

MODULE II (10 Hrs.)

Analysis of scalar field problems and vector field problems – Finite element analysis of fluid mechanics and heat transfer problems – Heat conduction – Energy and Navier stokes equations.

MODULE II1 (10 Hrs.)

Elasticity problems – Two and three dimensional elasticity problems – Bending of beams – The Euler – Bernoulli beam element, Plane stress and Euler – Bernoulli element – bending of elastic plate – classical plate model – Shear deformable plate model – Finite element.

MODULE 1V (10 Hrs.)

Eigen value and time dependent problems – Formulation of Eigen value problems – Time dependent problems – Applications – Non-linear problems – Finite element error analysis – Automatic mesh generation.

References:

1. J N Reddy, **An introduction to the infinite element method –** McGraw Hill book company
2. C Zienkiwiez, **The finite element method -** McGraw Hill Book company, New York
3. K H Huebner, **The finite element method of engineers** – John Wily & Sons, New York
4. L J Segerlind, **Applied finite element analysis** – John Willy & Sons, New York

MEC626 INDUSTRIAL MACHINE VISION

L	T	P	C
3	1	0	3

Module I: (9 Hrs.)

Introduction: Types of inspection tasks, Structure of image processing systems, examples

Image Preprocessing: Gray Scale transformations, Image arithmetic, Linear Filters, Other Filters

Positioning: Positioning of individual object, Orientation of individual object, Robot positioning

Module II: (9 Hrs.)

Segmentation: Regions of interest, Thresholding, Contour Tracing, Edge based methods, Template matching

Mark Identification: Bar code identification, Character identification, Identifying pin marked digits on metal, Print quality inspection

Module III: (10 Hrs.)

Classification: As function approximation, Instance based classifiers, Function based classifiers, Neural network classifiers

Dimension checking: Simple Gauging, Shape checking on punched parts, injection molded parts, High accuracy gauging of threads, Calibration.

Module IV: (11 Hrs.)

Image acquisition and illumination: Solid state sensors, Standard video cameras, other cameras, Transmission to computer, Optics, Lighting

Presence Verification: Simple presence verification, simple gauging for assembly verification, presence verification using classifiers

Object Features: Basic Features, Shape Descriptors, Gray Level Features

References:

1 Demant, et al, "Industrial Image Processing – Visual Quality Control in Manufacturing", Springer, 1999.

2 Gonzalez, et al, "Digital Image Processing Using MATLAB", Pearson Education, 2004.

3 Gonzalez & Woods, "Digital Image Processing - Second Edition", Pearson Education, 2002.

4 Batchelor & Whelan, "Intelligent Vision Systems for Industry", Springer Verlag, 2002.

MEC627 MICROFABRICATION

L	T	P	C
3	1	0	3

Module I: (9 Hrs.)
Introduction, Micrometrology and Materials Characterization, Simulation of Microfabrication processes.
Materials: Silicon, Thin Film Materials and Processes, Epitaxy, Thin-film Growth and Structure.

Module II: (10 Hrs.)
Basic Processes: Pattern Generation, Optical Lithography, Lithographic Patterns, Etching, Wafer Cleaning and Surface Preparation, Thermal Oxidation, Diffusion, Ion Implantation, Chemical-Mechanical Polishing, Bonding and Layer Transfer, Moulding and Stamping

Module III: (10 Hrs.)
Structures: Self aligned structures, Plasma etched structures, Wet-etched silican structures, Sacrificial and Released structures, Structures by Deposition.
Integration: Process Integration, CMOS Transistor Fabrication, Bipolar Technology, Multilevel Metallization, MEMS Process Integration, Processing on Non-silicon substrates.

Module IV: (10 Hrs.)
Tools: Tools for Microfabrication, Tools for Hot Processes, Vacuum and Plasmas, Tools for CVD and Epitaxy, Integrated Processing.
Manufacturing: Cleanrooms, Yield, Wafer Fab

References:

1. Sami Franssila, "Introduction to Micro Fabrication", John Wiley & Sons, Ltd,Sussex, 2004.
2. Marc J Madou, "Fundamentals of Microfabrication: The Science of Miniaturization", Second Edition, CRC Press, 2002.
3. Ivor Brodie and Julius J. Muray , "The Physics of Microfabrication", Plenum Publishing Corporation, 1993.
4. Mark James Jackson, "Microfabrication and Nanomanufacturing", CRC Press, 2005.

MEC628 TOOL ENGINEERING AND DESIGN

L	T	P	C
3	1	0	3

ModuleI[9hrs]

Design of cutting tools: tool materials – tool geometry – single point cutting tools– tipped tools – Milling cutters – Drills – form tools – Broaches – gear cutting tools – Grinding wheels
Cutting force analysis in turning & milling – design of tool holders for single point tools – Boring bars – selection of tools for machining applications.

Module II[10hrs]

Press tools: power presses – die cutting operations – centre of pressure – scrap strip lay out for blanking – press tonnage calculations – Progressive & Compound dies – die design for simple components.
Drawing dies – blank development – estimation of drawing force – blank holders & blank holding pressure – design & sketching of drawing dies for simple components – Bending dies & Combination tools.

ModuleIII [10hrs.]

Design of fixtures: standard work holding devices – principles of location and clamping – clamping methods and elements – quick-acting clamps – design & sketching of milling fixtures for simple components – Turning, Grinding and Welding fixtures.

ModuleIV[10hrs]

Design of Drill jigs: Drill bushings – types of jigs: Plate, Leaf, Turn over & Box Jigs – design & sketching of drill jigs for machining simple components
Fabrication of Jigs & Fixtures

References:

1. Cyril Donaldson, Lecain and Goold: Tool Design – Tata Mc Graw Hill publications
2. A Bhattacharyya: Metal Cutting – Theory and Practice – Central Book Agency Kolkata
3. Rodin P: Design and Production of Metal Cutting Tools – MIR publishers
4. HMT: Production Technology - Tata Mc Graw Hill publications
5. ASTME: Fundamentals of Tool Design – Prentice Hall
6. F W Wilson: Hand Book of Fixture Design - Mc Graw Hill publications

MEC629 DESIGN OF EXPERIMENTS

L	T	P	C
3	1	0	3

MODULE 1 (9 hrs.)

Revision of Statistics – Probability and random variables, Expected values and moments, sampling results, Linear combination of random variables.

Descriptive tools – Graphical and numerical statistics

Probability plots – Empirical CDF, Plotting on arithmetic graph paper, Interpreting normal plots, Half normal plot - Inferential statistics – Enumerative studies, Analytical studies.

MODULE II (10 hrs.)

Strategies of experimentation – Classical vs Statistical approaches, Deficiencies with analysis of historical data, Diagnosing the experimental environment, Good design requirements.

Basic Two-Level Factorial Experiments – Main effect estimation, Interactions, General 2^k Factorial Designs, Randomization, Significance of effects and interactions, judging significance when there are no replicates.

Additional Tools – Calculating the number of replicates for needed precision, testing for curvature by including center points in the design, Blocking Factorial experiments, Split plot designs.

MODULE III (10 hrs.)

Regression Analysis – Linear regression, multiple regression, quantifying model closeness, checking model assumptions, data transformation for linearity. Multiple level factorial experiments – Multiple level Factorial Designs, Mathematical model, judging the significance of effects, comparing means after ANOVA, applications of orthogonal contrasts, analysis of blocked and split plot experiments with multileveled factors.

Screening Designs – Fractionating Factorial Designs, Plakett – Burman screening designs, screening design with multiple level factors, sequential experimentation.

MODULE IV (10 hrs.)

Response Surface Methodology – Concepts and methods, Empirical quadratic model, Design considerations, Central Composite designs, Graphical interpretation of response surfaces, Other response surface designs.

Response Surface Model Fitting – Estimation of coefficients in quadratic Model, Checking model assumptions, statistical check of model adequacy, Trimming insignificant terms from a model, Exploring the response surface, Variability of predictions.

References:

1. Lawson, J. & Erjavec, J., "Modern Statistics for Engineering and Quality Improvement ", Thomson Duxbury, Indian EPZ edition $9.00.
2. Nibtginertm Diygkas C : **Design and Analysis of Experiments"**. Fifth ed, - John Wiley & Sons Inc.
3. Box, George E P, Hunter William G, Hunter Sturat J : **"Statistics for Experimenters" -** John Wiley & Sons inc.

MEC630 INDUSTRIAL TRIBOLOGY

L	T	P	C
3	1	0	3

MODULE 1 (10 Hrs.)

Introduction – Basic equations – Navier Stoke's equations – Derivation of Reynolds equation from Navier Stoke's equations – Energy equation, Idealised hydrodynamic bearings – Mechanisms of pressure development – Plane slider bearings – Idealized journal bearing – Infinitely long and Infinitely short bearings.

MODULE 1I (9 Hrs.)

Finite Bearings – Performance characteristics – Numerical solutions – Hydrodynamic instability – Bearing design – Analysis of externally pressurized and gas lubricated bearings.

MODULE 1II (10 Hrs.)

Surface interactions, surface topography, roughness measurements, Hertzian contacts, Real area of contact, Theories of friction, Friction of metals, Friction of non-metals, Temperature of sliding surfaces, Stick-slip, Rolling friction.

MODULE 1V (10 Hrs.)

Wear of metals, Adhesive wear, Abrasive wear, Corrosion and corrosion wear, erosion, Fatigue and impact wear, Wear of elastomers, Wear of ceramics and composite materials, Measurement of friction and wear, Introduction to Nanotribology.

References:

1. Majumdar, B.C., "Introduction to Tribology", A. H. Wheeler, Bangalore
2. Pinkus and Sternlicht, "Theory of hydrodynamic lubrication", John Wiley & Sons, New York
3. Cameron, A., "Basic lubrication theory", Wiley Estern Ltd
4. Bowden F.P. & Tabor D., "The Friction and Lubrication of Solids", Oxford University Press
5. Rabinowicz, E, "Friction & Wear of Metals", John Wiley & Sons, New York
6. Williams, J.A., "Engineering Tribology", Oxford University Press
7. Moore, D.F, "Principles and Application of Tribology", Pergamon Press, New York
8. Johnson, K.L., "Contact Mechanics", Cambridge University Press
9. Thomas, T.R., "Rough Surfaces", 2nd ed., Imperial College Press, London

MEC631 HYDRAULIC AND PNEUMATIC CONTROL SYSTEM

L	T	P	C
3	1	0	3

MODULE I (9 Hrs.)

Introduction to oil hydraulics and pneumatics, their advantages and limitations. ISO Symbols and standards in Oil Hydraulics and Pneumatics. Recent developments, applications

Basic types and constructions of Hydraulic pumps and motors. Ideal pump and motor analysis. Practical pump and motor analysis. Performance curves and parameters.

MODULE II (10 Hrs.)

Hydraulic control elements – direction, pressure and flow control valves. Valve configurations, General valve analysis, valve lap, flow forces and lateral forces on spool valves. Series and parallel pressure compensation flow control valves. Flapper valve analysis and Design. Analysis of valve controlled and pump controlled motor. Electrohydraulic servo valves – specification, selection and use of servo valves.

MODULE III (10 Hrs.)

Electro hydraulic servomechanisms – Electro hydraulic position control servos and velocity control servos. Nonlinearities in control systems (backlash, hysteresis, dead band and friction nonlinearities). Basic configurations of hydraulic power supplies – Bypass Regulated and Stroke Regulated Hydraulic Power Supplies. Heat generation and dissipation in hydraulic systems. Design and analysis of typical hydraulic circuits. Use of Displacement – Time and Travel-Step diagrams; Synchronization circuits and accumulator sizing. Meter-in, Meter-out and Bleed-off circuits; Fail Safe and Counter balancing circuits.

MODULE IV (10 Hrs.)

Components of a pneumatic system; Direction, flow and pressure control valves in pneumatic systems. Development of single and multiple actuator circuits; Valves for logic functions; Time delay valve; Exhaust and supply air throttling; Examples of typical circuits using Displacement – Time and Travel-Step diagrams. Will-dependent control, Travel dependent control and Time-dependent control, Combined Control, Program Control, Sequence Control, Electro-pneumatic control and air-hydraulic control. Applications in Assembly, Feeding, Metalworking, materials handling and plastics working.

References:

1. Blackburn J F, G Reethof and J L Shearer, **Fluid Power Control,** New York : Technology Press of M I T and Wiley, 1960
2. Ernst W, **Oil Hydraulic Power and its Industrial Applications** 2nd ed. New York, McGraw Hill, 1960
3. Lewis E E and H Stern, **Design of Hydraulic Control Systems** New York, McGraw-Hill, 1962

4. Morse A C, **Electro hydraulic Servomechanism**, New York, Mc Graw-Hill, 1963
5. Pippenger J J and R M Koff, **Fluid Power Control,** New York : McGraw-Hill, 1959
6. Fitch, Jr E C **Fluid Power Control Systems** New York : McGraw Hill, 1966
7. Khaimovitch : **Hydraulic and Pneumatic control of machine tools**
8. Merrit : **Hydraulic control systems**
9. Thoma Jean U, **Hydrostatic Power Transmission, Trade and Technical Press Surrey,** England 1964.
10. lan Meneal, **Hydraulic operation and control of Machine tools –** Ronald Press
11. Stewart, Hydraulic and Pneumatic power for production – Industrial press.

MEC632 VIBRATION AND NOISE IN MACHINE TOOLS

L	T	P	C
3	1	0	3

Module I (10 hrs)

Characteristics of Discrete tion, free vibration, natural frequency, forced vibration, vibration isolation, vibration testing equipments, Lagrange's equations of motion, analysis of linear system vibration using Lagrange's equations.

Module II (9 hrs)

Multi degree freedom systems, equations of motion, eigenvalue problem, Modal Analysis, general response of discrete linear systems, continuous systems, boundary value problems, free vibration eigen value problem, axial vibration of rods, bending vibration of bars.

Module III (10 hrs)

Random vibration, stationary and ergodic random process, autocorrelation, power spectral density function, response of linear systems to stationary random process, response of single degree freedom system to random excitation, cross correlation function, response of multi degree freedom system to random excitation, random excitation to continuous system.

Module IV (10 hrs)

Metal cutting force analysis, theory of chatter, modeling of machine tools, vibration analysis in typical machine tools, vibration in coupled machine tools (applying the knowledge from previous modules), effect of flexible mounting on vibration, Theory of impact dampers.

References:

1. Leonard Meirovich 'Elements of Vibration Analysis' International student edition.
2. J. P. Den Hartog 'Mechanical Vibrations' McGraw Hill Book Company Ltd.,
3. Poole and Safako ' Classical Mechanics' Goldstein, Pearson Education.
4. George Sweeney 'Vibration of machine tools – Machinery Publishing Co.

MEC633 FRACTURE MECHANICS & FAILURE ANALYSIS

L	T	P	C
3	1	0	3

Module I (10 hrs)

Introduction: significance of fracture mechanics; Griffith energy balance approach: Irwin's modification to the Griffith theory: Stress intensity approach; Crack tip plasticity; Fracture toughness: Subcritical crack growth influence of material behaviour: 1, II & III modes; Mixed mode problems.

Linear Elastic Fracture Mechanics (LEFM): Elastic stress field approach: Model elastic stress field equations Expressions for stresses and strains in the crack tip region; Finite specimen width; Superposition of stress intensity factors (SIF); SIF solutions for well known problems such as center cracked plate, single edge notched plate embedded elliptical cracks etc.

Module II (10 hrs)

Crack Tip Plasticity: Irwin plastic zone size; Dugdale approach; shape of plastic zone; state of stress in the crack tip region: Influence of stress state on fracture behavious.

Energy Balance Approach: Griffith energy balance approach; Relations for practical use; Determination of SIF from compliance: Slow stable crack growth and R-curve concept; Description of crack resistance.

LEFM Testing: Plane strain and plane stress fracture toughness testing: Determination of R-curves; Effects with yield strength and specimen thickness on fracture toughness; Practical use of fracture toughness and R-curve data.

Module III (10 hrs)

Elastic Plastic Fracture Mechanics (EPFM): Development of EPFM; J-integral; Crack opening displacement (COD) approach: COD design curve; Relation between J and COD; Tearing modulus concept; Standard Jk test and COD test.

Fatigue Crack Growth: Description of fatigue crack growth using stress intensity factor; Effects of stress ration and crack tip plasticity – crack closure; Prediction of fatigue crack growth under constant amplitude and variable amplitude loading: Fatigue crack growth from notches – the short crack problem.

Module IV (10 hrs)

Sustained Load Fracture: Time-to-failure (TTF) tests; Crack growth rate testing; Experimental problems; Method of predicting failure of a structural component; Practical significance of sustained load fracture testing.

Practical Problems: Though cracks emanating from holes; Corner cracks at holes ; Cracks approaching holes – fracture toughness of weldments; Service failure analysis; applications in pressure vessels, pipelines and stiffness sheet structures.

Reference:

1 Ewalds, H. L. & Wanhill, R. H. : Fracture Mechanics – Edward Arnold Edition.
2 Broek, D: Elementary Engineering Fracture mechanics – Sijthoff & Noordhoff International Publishers.
3 Kare Hellan: Introduction to Fracture Mechanics – McGraw Hill Book company.
4 Parashant Kumar: Elements of Fracture Mechanics – Wheeler Publishing

MEC634 EXPERIMENTAL STRESS ANALYSIS

L	T	P	C
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Module I (10 hours)

Analysis of stress and strain (review)
Basic equations in elasticity theory - formulation of problems – boundary conditions.
Basic concepts in measurement - Measurement of displacement, strain, pressure, force, torque etc.

ModuleII (10 hours)

Strain measurements Type of strain gauges (Mechanical, Electrical Resistance, acoustical, etc.,). Electrical resistance strain gauges - Gauge sensitivity and gauge factor - Environmental effects. Strain gauge circuits - The potentiometer and the Wheatstone bridge - Effects of lead wires, switches, etc., - Use of electrical - resistance strain gauges in transducer applications. Indicating and recording devices - Static and dynamic data recording - Data (digital and analogue) acquisition and processing systems - Telemetry systems. Strain-analysis methods - Rosette analysis.

ModuleIII (10 hours)

Photo elasticity: Basic optics – temporary double refraction - stress optic law - stress and bire-fringence - plane polariscope- circular polariscope - isoclinics - isochromatics - effects of stressed model in a plane and circular polariscope - dark field and light field arrangements - compensation techniques - photo elastic materials - material calibration. . Methods of stress separation - Frozen stress method. Introduction to holography and Moiré's techniques.

ModuleIV (9 hours)

Theory of brittle coating method - coating stresses, failure theories - brittle coating patterns - crack detection - ceramic based brittle coatings, Resin based brittle coatings - Test procedures for brittle coating analyses - analysis of brittle coating data.

References:

1. James. W. Dally & William E. Riley - Experimental Stress Analysis; Mc Graw Hill.
2. Richard G. Budynas : Advanced Strength and Applied Stress Analysis - Mc Graw Hill.
3. L. Sreenath, M. R. Raghavan, K. Lingaiah, G. Garghesha, B. Pant, K. Ramachandra: Experimental Stress Analysis; Tata Mc Graw Hill.
4. Timoshenko & Goodier: Theory of elasticity. Mc Graw Hill, New York.