OLD

Subject Code : MET 811
Title of the course : DESIGN OF EXPERIMENTS

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to:

CO1: Understand the basic concepts of optimization.
CO2: Understand the basic concepts of experimentation analysis like selection of random variables.
CO3: Construct mathematical model for random phenomena like Null Hypothesis and Alternative Hypothesis.
CO4: Obtain engineering solutions based on statistical analysis like Factorial Design and Taguchi Method.
CO5: Analyze the variance like one-way ANOVA, two ways ANOVA, numerical on ANOVA, Z-test and T test

Pre-requisite knowledge:

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO10	PO11	PO12
CO1	S	S	S	S	M	--	--	--	--	M	W	-
CO2	S	S	S	S	M	--	--	--	--	M	W	-
CO3	S	S	S	S	M	--	--	--	S	M	M	-
CO4	S	S	S	S	M	--	--	--	--	M	M	-
CO5	S	S	S	S	M				S			S

Theory:

SECTION I

INTRODUCTION (8 Hrs)
Brief introduction of optimization techniques, Strategy of experimentation, Basic principles of Design, Terminology used in Design of Experiment, Guidelines for designing experiments, Basic statistical concepts: Types of Data, Graphical representation of Data, Measures of Central Tendency and Dispersion, Skewness.

SIMPLE COMPARATIVE EXPERIMENTS (8 Hrs)
Sampling and sampling Distribution, Test of significance for single mean and for difference of means of two samples, Inferences about the Differences in means: randomized designs, Inferences about the Differences in means: Paired comparison Designs, Inferences about the Variances of Normal Distributions. Test of significance based on t, F and Chi square distribution.

FITTING REGRESSION MODELS (8 Hrs)
Introduction, Linear regression models, Estimate of parameters in linear regression models, The

method of least square, Hypothesis testing : Null Hypothesis, Alternative Hypothesis, Prediction of new response observations, Testing for lack of fit.

SECTION II

FACTORIAL DESIGN (8 Hrs)

Basic definition and principles, Advantages of factorials, Types of factorial design: Full factor factorial design and fraction factorial design, Design Matrix, Development of mathematical model, Regression model diagnostics.

TAGUCHI METHOD **(**8 Hrs)

Introduction, Concept design, Parameter design, Tolerance design, Orthogonal array experiments Taguchi quality loss function, Signal-to Noise ratio, Quality characteristics, Parameter optimization experiment, Parameter design case study.

ANALYSIS OF VARIANCE (ANOVA) (8 Hrs)

Introduction, One way ANOVA process, Two way ANOVA process, Degrees of freedom, Case studies on Factorial design, Taguchi Method and ANOVA.

Books Recommended

1. Design and Analysis of Experiments, Douglas C Montgomery, John Wiley
2. Statistical Design and Analysis of Experiments, John P.W.M., Macmillan,
3. Introduction to Linear Regression Analysis, Montgomery D.C., Runger G. C.,
4. Introduction to Quality Engineering, Taguchi, G., Asian Productivity Organisation, UNIPUB, White Plains, New York
5. Statistical Methods for Engineering and Sciences, Taneja HC, IK International Publishing house Pvt Ltd.
6. Statistical Analysis for Engineers and Scientists, J. Wesley Barnes, McGraw Hill Inc.

Subject Code : MET 812
Title of the course : Theory of Metal Cutting

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:

After successful completion of course, the students should be able to

CO1: To attain knowledge on the fundamentals and empirical relations used in metal cutting theory for the understanding of basic concepts, chip formation mechanism, cutting forces produced and their impact on machining, optimization of machining operations.

CO2: To have awareness on different cutting tool materials, their composition, advantages and applications.

CO3: Study the design considerations and development of lathe, drilling and milling dynamometers.

CO4: Gain knowledge on thermodynamics of machining and economics of machining.

CO5: To impart knowledge on tool wear, wear mechanism of cutting tools, tool failure, vibrations and chattering in metal cutting operations, machinability and tool life principles.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	S	S	S	M	M	M	W	W	M	S
CO2	M	M	S	S	S	M	M	M	W	W	M	S
CO3	M	M	S	S	S	M	M	M	W	W	M	S
CO4	M	M	S	S	S	M	M	M	W	W	M	S
CO5	M	M	S	S	S	M	M	M	W	W	M	S

Theory

Course Description	**Lecture(s)**
Unit-I	
Metal Machining	**04**
Machining, definition and objectives. Geometry of cutting tools; turning, milling and drilling in different reference systems like machine reference system, tool reference system and work reference system. Sharpening and re-sharpening of cutting tools.	
Chip Formation Mechanism	**08**
Mechanics of chip formation by single point cutting tools, drills and milling cutters. Types of chips, and their characteristics, Effective rake.	
Force System in Machining	**08**
Mechanics of machining, theoretical estimation and experimental determination of cutting forces and power consumption.	
Dynamometers	**06**

Dynamometers, types, design, construction and use.	
Unit-II	
Thermal Aspect in Machining	**06**
Thermodynamics of machining, sources of heat generation, cutting temperature modelling measurement of cutting temperature. cutting fluids: purpose, essential characteristics, selections and methods of application.	
Tool Wear and Tool Life	**06**
Cutting tools; methods of failure, mechanics of tool wear, essential properties, assessment of tool life and cutting tool materials.	
Economics of Machining	**06**
Economics of machining; principal objectives, main parameters and their role on cutting forces cutting temperature, tool life and surface quality, section of optimum combination of parameters.	
Tool Vibrations and Chattering	**04**
Causes of vibration and chatter in machining and their remedy.	

Total = 48

Recommended Books

Title	***Author(s)***	***Publisher***
Manufacturing Science	Malik & Ghosh	EWP
Production Engineering Science	Pandey & Singh	Standard Publishers
Metal cutting Theory	A.Bhattacharya	Central Book Publishers

Subject Code : MET 813
Title of the course : Modelling and Simulation of Manufacturing Systems

L	T	P	Credits	Weekly Load
3	1	2	5	5

Course Outcomes:
After successful completion of course, the students should be able to:

CO1: Identify the underlying concepts; advantages, limitations and usefulness of modeling & simulation of engineering systems in general, and that of manufacturing systems in particular**.**
CO2: Construct mathematical model for any continuous or discrete engineering systems.
CO3: Obtain random samples by generating & testing random numbers [0, 1], and converting to random variates as per appropriate statistical (probability) distribution.
CO4: Simulate the problems of manufacturing systems and management science using appropriate set of random samples.
CO5: Design the simulation experiment for static, dynamic and stochastic systems.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											S
CO2	S	S										S
CO3					S							M
CO4		S		S	S							S
CO5	S											S

Theory:

SECTION-I

Introduction Introduction, concept of system & environment, elements of systems, types of systems, system modeling, types of models. System simulation, simulation as a management laboratory, advantages & limitations of system simulation. 6

Simulation of Continuous system Examples of continuous system simulation – pure pursuit problem, chemical and neuclear reactor problem, etc., characteristics of continuous systems, comparison of numerical integration with continuous system simulation, selection of integration formula for simulation. 7

Simulation of Discrete System Time flow mechanisms. Generation of random numbers, testing of random numbers for uniformity & statistical independence. Discrete and continuous probability density functions (binomial, uniform, exponential, normal and beta density functions). Generation of random variates for discrete probability distribution, generation of random variates for continuous probability distribution. Combination of discrete-event and continuous models. 7

Simulation of queuing system Concept of queuing theory, characteristics of queues, measure of system performance, Kendell's notation. Simulation of single-server and double-server queues. Queues involving complex arrivals and service times with balking, reneging and jockeying, stationary and time dependent queue, auto covariance and auto correlation function, auto correlation effects in queuing system. 7

SECTION-II

Simulation of inventory system Rudiments of inventory theory – analytical approach. Necessity of simulation, simulation of inventory systems. Demand forecasting and regression analysis; time series analysis, exponential smoothing and simulation based forecasting approaches. 6

Simulation of project management problems Introduction to PERT & CPM for project management. Necessity of simulation. Simulation of project management problem(s). 6

Design of simulation experiments Length of simulation run, run length for static stochastic simulation, run length for dynamic stochastic simulation - elimination of transients (initial bias), auto-correlated observations, blocking, etc. Variance reduction techniques - antithetic sampling, correlated sampling, importance sampling, control variates, stratified sampling, etc. 6

Simulation Languages Continuous and discrete simulation languages block structure continuous languages, special purpose simulation languages. 4

Recommended Books: Title	**Author(s)**	**Publisher**
Simulation and Modeling	Loffick	Tata McGraw Hill
System Simulation with Digital Computer	Deo Narsingh	Prentice Hall of India
System Simulation	D.S. Hira	S. Chand & Co.
System Simulation	Gorden	Prentice Hall
Simulation Modeling & Analysis	David Kelton	Tata McGraw Hill

Subject Code : MET 814
Title of the course : Computer Integrated Manufacturing Systems

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to:

CO1: Enhance the knowledge of applications of computers in manufacturing processes.
CO2: Improve the management skills.
CO3: Able to attempt few problems on automation.
CO4: Develop the knowledge of modern inspection techniques.
CO5: Able to attempt project management problems.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1					S	S				S		
CO2		S									S	
CO3					S							
CO4				S	S							
CO5					S		S					S

Theory:

SECTION-I

Computer Aided Manufacturing (review): Introduction to conventional and modern manufacturing systems. NC, CNC, DNC and adaptive control.

Material handling: Principles and characteristics of material handling systems. Conveyor Systems, Automated storage and retrieval system (AS/RS), AGV.

Robotics: Introduction, Basic motions, Precision of movements, Introduction to robot programming, End of arm tooling, Sensors, robot terminology, case study like pick and place of bolt for processing.

Automated Inspection Quality Control: Automated inspection, introduction to Coordinate measuring machines(CMM), Surface measurements, machine vision, other optical inspection techniques, non contact non optical inspection techniques.

SECTION-II

Flexible Manufacturing Systems: Cellular manufacturing, components of FMS, types, design, implementation issues.

Information management: Group technology, CAPP, Material requirement planning (MRP), Capacity Planning, Shop floor control, Inventory control, MRP-II, ERP.

Project management: Introduction, time management, team management, cost management, risk management, introduction to lean manufacturing, cost analysis.

Recommended Books: Title	**Author(s)**	**Publisher**
Automation, Production Systems and Computer Integrated Manufacturing	Groover, M. P	PHI
Flexible Manufacturing System	Shivanand, Benal, Koti	New Age
CAD/CAM Computer-Aided Design and Manufacuring	Groover & Zimmers	Pearson
Computer-aided Manufacturing	Chang, Wysk, Wang	PHI
Project Management	Heerkensens	McGraw Hill

Subject Code : MET 815 A (Elective-I)
Title of the course : Finite Element Methods

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to:

CO1: Understand strain-displacement and stress-strain relations with and without the temperature effect.
CO2: Explain various numerical methods which can be applied to mechanical problems.
CO3: Discretize the continuum domain into finite element mesh using various types of elements.
CO4: Apply the finite element methods to solve static, scalar field and dynamic problems.
CO5: Formulate the computer implementation of the finite element methods.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2	M	S										
CO3				M								
CO4				S							M	
CO5				S					W			M

Theory:

SECTION-I 12

Introduction & Fundamental Concepts Historical Background, Stresses and equilibrium, Boundary Conditions, Strain-Displacement Relations, Stress-Strain Relations, Temperature Effects, Vectors and Matrices.

Different Methods and Applications Classification of Differential Equations, Rayleigh-Ritz Method, Galerkin's Method, Point Collocation Method, Least Square Method, Weighted Residual Method, Variational Formulation.

1-D FE Modeling Finite Element Modeling, Coordinates and Shape Functions, 12
Generalized Coordinates, Natural Coordinates in 1D, 2D and 3D, Coordinate Transformation, Assembly of Global Stiffness matrix and Load vector, Properties of Stiffness Matrix, Treatment of Boundary Conditions and Temperature Effects. Truss and Beam Elements. Simple problems.

2-D FE Modeling Finite Element Modeling, Constant Strain Triangle (CST).

SECTION-II

2-D FE Modeling The Four Node Quadrilateral, Numerical Integration, Higher Order 12 Elements; Nine Node Quadrilateral, Eight Node Quadrilaterals, Six Node Triangle.

Truss Introduction, Plane Trusses, Assembly of Global Stiffness Matrix and load vector, displacement.

Higher-Order Elements Plate Bending, C^0 and C^1 Elements, Non-conforming Elements and Patch Test.

Computer Implementation Introduction; Computer Program Organization for Calculation of System Matrices.

Dynamic Considerations Element Mass Matrices, Evaluation of Eigen Values and Eigen Vectors. (Introduction)

Scalar Field Problems Introduction, Steady-state heat transfer, Potential Flow, Fluid Flow in Ducts.

Recommended Books:Title	**Author(s)**	**Publisher**
Introduction to Finite Elements in Engineering	Chandrupatla and Belegundu	PHI
Finite Element Procedures	K.J. Bathe	PHI
An Introduction to Finite Element Method	J. N. Reddy	TMH
The Finite Element Methods for Engineers	Huebner	John Wiley
The Finite Element Method	O.C. Zienkiewicz	TMH
Finite Element Analysis	Buchanan	McGraw Hill

Subject Code : MET 815 B (Elective-I)
Title of the course : DIAGNOSTIC MAINTENANCE AND MONITORING

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to:

CO1: Understand the importance of monitoring and diagnostic maintenance of a mechanical system.
CO2: Understand the basic principles of diagnostic methods and the circumstances where they are applicable.
CO3: Understand the different attributes of a machine (*through use of appropriate tools*) in relation to its health.
CO4: Develop analytical ability to process and conclude from the machine health attributes.
CO5: Model diagnostic maintenance and monitoring system in an environment friendly manner.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2	S	S										
CO3		S	S		S							
CO4	S			S								S
CO5			S	S			S		M		S	

Theory:

SECTION-I

Introduction 12

Introduction to maintenance techniques, maintenance Strategies, Classifications (Plant maintenance, Running Maintenance, Shut Down, Emergency corrective, curative, Breakdown, preventive predictive, Reliability, Total productive Maintenance, Guidelines for selecting best strategy.

Fault Tree analysis 12

Fault Tree analysis, Methodology for tree development, Family tree definitions in symbols. Fault Tree construction, fault tree simplification, fault tree evaluation, common cause failure, Probability evaluation in fault trees, Simulation approach

Wear analysis

Wear analysis through Thermo-graphy and Ferro-graphy

Condition Monitoring 12

Various Techniques of condition Monitoring, condition based Maintenance, visual monitoring, performance monitoring, vibration monitoring, war debris monitoring, Decision elements in condition based maintenance detection, diagnosis, Prescription, Benefits of condition maintenance

Diagnostic maintenance 12

Application of diagnostic maintenance to Industrial Machine & plants. Case studies.

Recommended Books:Title	**Author(s)**	**Publisher**
Diagnostic maintenance & condition Monitoring	Kelly	Butterworth & Co.
Maintenance and spare parts management	Krishan G	Prentice Hall
Maintenance Engineering Handbook	Higgins	McGraw Hill
RAM in manufacturing	Gandhi & Chawla	Proceedings of SERC, IIT
Engineering Maintenance Management	Nielsel Benjamin	Maries

Subject Code : MET 815 C (Elective-I)
Title of the course : Advanced Fabrication and Joining Procesess

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to

CO1: Understand importance of monitoring and diagnostic maintenance of a mechanical system.

CO2: Understanding of basic principle of diagnostic methods and the circumstances in which they are suitable to use.

CO3: Understanding different attributes of a machine (through use of appropriate tools) in relation to its health.

CO4: Develop analytical ability to process and conclude from the machine health attributes.

CO5: Model diagnostic maintenance and monitoring system in environment sustainable manner.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2	S	S										
CO3		S	S		S							
CO4	S			S								S
CO5			S	S			S		M		S	

Theory:

SECTION-I

Introduction 12

Introduction to maintenance techniques, maintenance Strategies, Classifications (Plant maintenance, Running Maintenance, Shut Down, Emergency corrective, curative, Breakdown, preventive predictive, Reliability, Total productive Maintenance, Guidelines for selecting best strategy.

Fault Tree analysis 12

Fault Tree analysis, Methodology for tree development, Family tree definitions in symbols. Fault Tree construction, fault tree simplification, fault tree evaluation, common cause failure, Probability evaluation in fault trees, Simulation approach

Wear analysis
Wear analysis through Thermo-graphy and Ferro-graphy

SECTION-II

Condition Monitoring 12

Various Techniques of condition Monitoring, condition based Maintenance, visual monitoring, performance monitoring, vibration monitoring, war debris monitoring, Decision elements in condition based maintenance detection, diagnosis, Prescription, Benefits of condition maintenance

Diagnostic maintenance 12

Application of diagnostic maintenance to Industrial Machine & plants. Case studies.

Recommended Books:

Title	***Author(s)***	***Publisher***
Diagnostic maintenance & condition Monitoring	Kelly	Butterworth & Co.
Maintenance and spare parts management	Krishan G	Prentice Hall
Maintenance Engineering Handbook	Higgins	McGraw Hill
RAM in manufacturing	Gandhi & Chawla	Proceedings of SERC, IIT
Engineering Maintenance Management	Nielsel Benjamin	Maries

Subject Code : MET 815 D (Elective-I)

Title of the course : IT IN MANUFACTURING

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to:

CO1: Develop the knowledge of application of computers in Designing.
CO2: Develop the knowledge of application of computers in Manufacturing.
CO3: Design and analyze the modelling of parts.
CO4: Develop knowledge of Automated inspection quality control.
CO5: Ability to develop introductory knowledge in Robotics & Rapid Protyping.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S		S							S		S
CO2	S										S	S
CO3	S	S	S		S					S		S
CO4	S				S		S			S		S
CO5	S				S							S

Theory:

SECTION-I

Computer Aided Design: Curves: Parametric representation, Hermite, Bezier and B-spline Curves. Surfaces: plane, cylindrical, ruled, coons patch, sweep, Bezier, B-spline. Solids: Introduction, Solid representation, B-rep, CSG, Solid manipulations. Geometric transformations. Modeling and object hierarchy. Hidden lines, edge and surface removal. Introduction to shading & rendering of surfaces and solids. Geometric Tolerances: Background, Geometric Tolerances-ASME, Interpretation.

12

Computer Aided Manufacturing (review): Introduction to conventional and modern manufacturing systems. NC, CNC, DNC systems, functions, their components, advantages and disadvantages.Adaptive control system: Introduction, types, ACC, ACO area of application, advantages.

Material handling: Principles of material handling. Conveyor System: Types of conveyors, Conveyor operation and features. Automated storage and retrieval system (AS/RS): Storage

system performance, Storage location strategies, Automated storage systems, Automated storage and retrieval system. 12

SECTION-II

Robotics: Introduction, History, Definition, Classification, Description of manipulators, Basic motions, Precision of movements, PTP and CP robots, Types of drives, Introduction to robot programming, Robot programming languages, End of arm tooling, Sensors used in robots, Robot safety and economic analysis

Automated Inspection Quality Control: Inspection fundamentals, Automated inspection, Contact and non contact inspection techniques, Coordinate measuring machines, construction, operation, software, applications and benefits, Surface measurements, machine vision, other optical inspection techniques, non contact non optical inspection techniques.

12

Computer Integrated Manufacturing System: Introduction, Types, machine tool and related equipment, material handling system, Computer control system, Human labor in manufacturing system, role of computers in CIMS, Introduction to CIM software, Benefits of CIMS.

ERP, FOF: Computer managing system, Enterprise Resource Planning (ERP), Factory of future.

Rapid Prototyping: Principles, Applications, Techniques: Strereolithography (SLA), Selective Laser Sintering (SLS), fused deposition modeling (FDM), laminated object manufacturing (LOM), Solid ground curing (SGC), three dimensional printing (3DP). 12

Recommended Books: Title	**Author(s)**	**Publisher**
Automation, Production Systems and Computer Integrated Manufacturing	Groover, M. P	PHI
CAD/CAM Theory & Practice	Zeid, Ibrahim	TMH
CAD/CAM Computer-Aided Design and Manufacuring	Groover & Zimmers	Pearson
Computer-aided Manufacturing	Chang, Wysk, Wang	PHI

Subject Code : MET 821
Title of the course : Advanced Machining Processes and analysis

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:

After successful completion of course, the students should be able to

CO1: Understand advantages and applications of non-conventional machining processes in comparison to the conventional machining processes.

CO2: Identify the mechanism of metal removal and the equipment used in non-conventional machining processes for material removal using mechanical energy (USM, AJM, WJM).

CO3: Identify the mechanism of metal removal and equipment used in non-conventional machining processes for material removal using electro-chemical energy (ECM and ECG).

CO4: Identify the mechanism of metal removal and equipment used in non-conventional machining processes using thermal energy (EBM, EDM, LBM, PAM and IBM).

CO5: Identify the mechanism of metal removal and equipment used in non conventional machining processes using chemical energy (CHM).

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO12
CO1	S	S	S	S		M		M				M
CO2	S	S	S	S		M		M				M
CO3	S	S	S	S		M		M				M
CO4	S	S	S	S		M		M				M
CO5	S	S	S	S		M		M				M

Theory:

SECTION-I

Mechanical Material Removal Processes 12

Introduction, Classification of various modern machining processes. Material removal mechanism on ductile, brittle and other materials. Considerations in process selection

Working principle, selection of processes, Material removal rate, Horn design, process capabilities, applications & limitations of the Ultrasonic machining (USM). Effect of process parameters on responses.

Abrasives Flow Machining 12

Working principles, mechanism of material removal study and selection of process parameters, machining characteristics, AFM, Abrasive jet Machining , (AJM), Water jet machining (WJM), Abrasive Flow Finishing Process, Abrasive water jet Machining (AWJM), MRAFF, UAAFF. Determination of MRR, surface texture and analysis of AFM processes. Applications & limitations of the processes.

SECTION-II

Chemical and Electro Chemical Machining Processes 12

Principle of operation, mechanism of material removal, study of equipment and selection of process parameters, process capabilities, tool design applications & limitations:

Chemical machining (CM), Electro chemical machining (ECM). Electrochemical Honing, Electrochemical de-burring, Electro stream and shaped Tube Electrolytic Machining, Electro jet machining, Electro grinding. Selection and deposition layer thickness of mask

Thermal Metal Removal Processes 12

Source of thermal energy, Electric Discharge machining (EDM), Electron Beam machining (EBM), Ion-beam machining (IBM), and Laser beam machining (LBM) Effect of process parameters on response characteristics; calculation of MRR. Overview of conventional machining.

Concept of Hybrid Machining

Basic principle, operation, parametric effect of ECSM, TWECDM, ECG.

Recommended Books:

Title	***Author(s)***	***Publisher***
Non conventional Machining	P.K. Mishra	Narsoa
Modern machining methods	Pandey & Shan	TMH
Principles of Electrochemical Machining	Mc Geough	Chapman & Hall
Plasma, Electron and Laser beam Technology	Arata. A	ASM
Laser Machining-Theory & Practice	George Chryssolouris	Springer

Subject Code : MET 822
Title of the course : INDUSTRIAL AUTOMATION AND MECHATRONICS

L	T	P	Credits	Weekly Load
3	1	2	5	5

Course Outcomes:
After successful completion of course, the students should be able to
CO1: Make interface of computers with the outside world
CO2: Construct the model of physical system dynamics
CO3: Carry out simulation and analysis of complex physical systems
CO4: Understand the principles of Automation of Manufacturing processes.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	M	S						M
CO2	S	S	S	S	M	S						M
CO3	S	S	S	S	M	S						M
CO4	S	S	S	S	M	S						M

Theory: SECTION-I

Fundamentals of Electrical and Electronics 12

Review of semiconductor devices, operational amplifier, Configurations: Inverting, summing, integrating and differentiating. Registers, capacitors, potentiometer, R-L, RLC. The Mechatronics approach: A methodology for integrated design of Mechanical, Electronics, Electrical, Control, computer and Instrumentation, Linking between electrical and mechanical devices.

Pneumatics and Hydraulics 12

Hydraulic and Pneumatic Power supplies, Different types of valves: Direction control valves, Terminolgy, Pressure control valves, Speed control valves, Check Valves. Actuators: Single acting and double acting, Classification, Cylinser sequencing and process control. Simple cuircuits and its simulation.

Digital Electronics and Data Acquisition 12

Number systems: Binary, Octal, Hexadecimal, Conversion from Binary to Decimal, Octal and Hexadecimal and vice–versa, Binary arithmetic: Addition, subtraction, Multiplication and division

Boolean Algebra: Laws, De-Morgan's laws, Logic Gates, Truth tables, Karnaugh maps and logic circuits. Generation of Boolean function from truth tables and simplification.

Optical encoder and strain gauge sensors.

Concepts of digital and analog systems, Digital to analog conversion (DAC): R-2R and summing Op-amp circuit, Analog to digital conversion (ADC): successive approximation method.

Programs for DI, DO, DA and AD for PCL 208 card.

SECTION-II

Control systems Mathematical modeling of physical systems, system equations, Performance characteristics of First order and second order system, Basics of Bond Graphs, Elements of Bond Graphs, generation of Bond Graphs of simple systems, Deriving system equations in State Space from Bond Graphs. Simulation of Physical system dynamics. 12

Microprocessor and Programmable Logic Controller Introduction to 8085, Architecture, programming, I/O, Computer interfacing. 12

Function of PLC, Architecture, Components of PLC, selection of PLC, Ladder Logic diagram, Logic functions: latching, sequencing, counters, shift registers, jumpers, manipulation of data, arithmetic operations 12

Recommended Books:Title	**Author(s)**	**Publisher**
Mechatronics	W. Bolton	Pearson Education
Pneumatic system	Majumdar	TMH
Hydraulic and Pneumatic systems	Andrew Parr	TMH
Mechatronics	Mahalik	TMH
Mechatronics	Ramachandran	Wiley India

Subject Code : MET 823
Title of the course : ADVANCED OPTIMIZATION TECHNIQUES

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to

CO1: Understand and formulate solution intricacies of linear programming problem, and obtain the sensitivity of optimal solution using graphical approach.

CO2: Learn the underlying concepts of nonlinear programming problem, including solution of nonlinear programming problem without constraints, and those with $\leq$, = and $\geq$ type constraints.

CO3: Formulate the integer programming problems for engineering applications, and to acquire the familiarity with the conventional methods of solution.

CO4: Understand the difference between traditional and nontraditional optimization techniques, with regard to advantages, limitation and applications.

CO5: Apply the simple genetic algorithm to an optimization problem.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S								S
CO2	S	S	S	S								S
CO3	S	S	S	S								S
CO4	S	S	S	S								M
CO5	S	S	S	S	S							S

Theory:

Section-I

Linear programming Modelling of linear programming problem – a few examples; Solution of linear programming problem – simplex method, two-phase method, M-method; Sensitivity analysis – graphical approach. 12

Non-linear programming Convex and non-convex search space, Kuhn-Tucker conditions, Hessian matrix; Transformation of constrained optimization problems into unconstrained ones – penalty function approach; Direct search – variable elimination method, random search method. 12

Section-II

Integer Programming Modelling of integer programming problem – a few examples; Solution of integer programming problem – branch & bound algorithm, cutting-plane algorithm; Traveling salesman problem – formulation, solution and practical applications. 12

Heuristic models Limitations of traditional optimization approaches to solve real world problems, Population based optimization techniques, Simple genetic algorithms – introduction, representation of variables, fitness function, genetic operators – reproduction, crossover, mutation; Advantages and limitations of population based optimization techniques over the point-to-point based ones, Multi objective optimization, case study. 12

Recommended Books:Title	**Author(s)**	**Publisher**
Operations Research	Taha, H. A.	PHI
Optimization of Engineering Design	Deb, K.	PHI
Operations Research	D.S. Hira, P. K. Gupta	S. Chand
Optimization techniques	Rao	New Age international

Subject Code : MET 824
Title of the course : PRODUCTION MANAGEMENT AND QUALITY ENGINEERING

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to
CO1: Apply various forecasting techniques.
CO2: Conduct performance measurements of any supply chain.
CO3: Apply the JIT production system to industry.
CO4: Understand inventory control systems.
CO5: Select statistical tools of quality control tools.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S							S
CO2	S	S	S	S	S							S
CO3	S	S	S	S	S							S
CO4	S	S	S	S	S							S
CO5	S	S	S	S	S							S

Theory:

SECTION-I (Production Management)

Production & Operation Management: Introduction, Role of Industrial Engineering in Industry, Functional areas of Production Management, Role of Production Management in Industry, Classification of Production System, Environmental issues in Production System.

Essentials of Operation management: Operation Strategy, Advance Production Systems, Inventory Control, MRP, MRP-II, ERP, Aggregate Planning, Operation Scheduling, Project Scheduling, Forecasting.

Just in Time Production System: Principle of Just-In-Time, Kanban System, Single Minute Exchange of Dies, Meeting Demands Through Flexibility, Autonomous Defects Control, 5S, Lean Manufacturing.

Supply Chain Management: Introduction, Transportation Problem, Determining Delivery Routes in Supply Chains, Role of Information in the Supply Chain, Multilevel Distribution Systems, Case Studies.

Theory of Constraints: Goal and Performance Measures of a Firm, Bottlenecks and Capacity-Constrained Resources Production Control by Drum, Buffer and Rope, What and How Much to Produce?, OPT Rules of Production Scheduling, Theory of Constraints case Studies.

Facilities Layout and Location: Patterns of Flow and From-To Chart, Assignment Model, Computerized Layout Techniques, Locating New Facilities, Single-Facility Rectilinear Distance Location Problem, Euclidean Distance Problems.

SECTION-II (Quality Engineering)

Quality Control: Statistical concepts in quality control, Graphical representation of ground data, Continuous & discrete probability distributions, central limit theorem, Chi-square test, Introduction to quality control, process control and product control, chance and assignable causes of quality variation, Type I and Type II errors, Theory of runs, interpretation of out of control points, Probability limits, initiation of control charts, trial control limits, process capability studies.

Control charts: Control charts for variables, Group control charts, Arithmetic moving X ad R charts, Geometric Moving charts, X control charts with reject limits, Steady trend in process average with cost dispersion, trend chart with sloping limits, CUSUM

Sampling plans: Probability theory, hyper-geometric, Binomial and Poisson distributions,

Acceptance inspection 100% inspection, no Inspection and sampling inspection, operating

characteristic curve, Type A and Type B, O.C curves, single, Double and multiple sampling plans, Sequential sampling plans, procedure's risk ad consumer's risk, difference quality level, Average outgoing quality curve, average outgoing quality limit.

Quality Management Systems: Economics of product inspection, selection of economic sampling plans, Product quality and reliability, failure data analysis ad life testing, elements of total quality control quality assurance, ISO9000 quality system & ISO 14000/15001 System.

Recommended Books:

S. No.	**Title of Books**	**Author(s) and Publisher**
1.	Production and Operation Management	S.P.Singh, Vikas Publishers, Delhi
2.	Statistical Quality Control	Grant & Leave worth McGraw Hill
3.	Quality Control Systems	J.R. Taylor McGraw-Hill
4.	Statistical Quality Control	M.Mhajan, Dhanpat Rai

5.	Total Quality Control	A.V. Taylor McGraw-Hill
6.	Industrial Engineering & Management	Ravi Shankar, McGraw-Hill

Subject Code : MET 825 A (Elective-II)

Title of the course : Fabrication & Processing of Composites & Ceramics

L	T	P	Credits	Weekly Load
3	1	0	4	4

COURSE OUTCOMES:

After successful completion of course, the students should be able to:

CO1: Comprehend with the application of manufacturing process of composite materials.

CO2: Differentiate the mechanical behaviour of layered composites compared to isotropic materials

CO3: Describe fundamentals of fabrication processes for polymer matrix, metal matrix and ceramic matrix composites.

CO4: Select a suitable composite material for specific application.

CO5: Analyse and extend a given topic of course subject, compose a report and effectively communicate the essentials through an oral presentation.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	M	M			M		M	M
CO2	S	S	S	S		M					M	M
CO3	S	S	S	S	M	M		M				M
CO4	S	S	S	S		M			M		M	M
CO5	S	S	S	S		M		S				S

Theory:

SECTION I

Introduction General introduction to composites; historical background; concept of matrix and reinforcement and particulates. 12

Matrix and reinforcement Types of matrix and reinforcement; Whiskers; volume fraction and weight fraction; Fiber architecture; fiber packing arrangements,

Fabrication methods of polymer composites liquid resin impregnation routes, pressurized consolidation of resin prepegs, consolidation of resin molding compounds, injection molding of thermoplastics, hot press molding of thermoplastics. 12

Fabrication of ceramic composites powder based routes, layered ceramic composites, carbon/carbon composites and applications.

SECTION II

Fabrication routes of metal matrix composites Squeeze infiltration, stir casting, spray deposition, powder blending and consolidation, diffusion bonding of foils, PVD; CVD 12

Testing and characterization Different tests like internal stress measurement by diffraction, metallographic preparation with special emphasis to metal matrix composites

Secondary processing and application of composites Secondary processing like machining, joining, extrusion of composites; Application and case studies. 12

Recommended Books:

Title	Author(s)	Publisher
An Introduction to Composite Materials	Hull D and Clyne TW	Cambridge University Press
Metal matrix composite	R.K.Everret & R.J. Arsenault	Academic Press
Introduction to metal Matrix Composite Composite Materials Science and Engineering Composite Materials and Processing Mechanics of Composite Materials Fiber-Reinforced Composites Materials, Manufacturing and Design	T. W. Clyne & P. J. Withers **Chawla**, Krishan K M. Balasubramanian Jones, R.M P. K. Mallick	Cambridge Press Springer CRC Press Taylor and Francis CRC Press

Subject Code : MET 825 B (Elective-II)
Title of the course : Tribology

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:

After successful completion of course, the students should be able to

CO1: Understand importance of study of surface in contact during motion.

CO2: Understand the laws of friction, wear, lubricants, characteristics of the contact surfaces.

CO3: Understand different attributes in tribological measurements (*through use of appropriate tools*) in relation to its health.

CO4: Develop analytical ability to process tribological attributes and examine the health of equipments.

CO5: Design a lubricant/rotary/reciprocating/sliding system for extended machine life.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S								
CO2	S	S	S	S								M
CO3	S	S	S	S	S							M
CO4	S	S	S	S								S
CO5	S	S	S	S			S		M		S	

Theory:

SECTION-I

Introduction 12

Friction, wear and lubrication, Types of Engg. Contacts: conforming and non-conforming. Types of Motion, rubbing, sliding, oscillating, Rolling and surface of interactions, elastic and plastic deformations, properties of materials, surface energy and flash temp. theory.

Friction 12

Law of sliding friction, concept of adhesion. Taylor's model of friction, Measurement of friction.

Wear

Laws of wear, types of wear such as adhesive, declamation, abrasive, fatigue, corrosive, fretting erosive, electrical and oxidative. Measurement of wear in dry atmosphere and different environments preventive, control of wear, wear of cutting tool and dies, study of abrasion in grinding, lapping and honing.

SECTION-II

Lubricants 12

Mechanisms of lubricants, boundary, squeeze film hydrodynamic and elasto hydrodynamic and hydrostatic lubricants plasto hydrodynamic lubricants, solution of Reynolds equation in two and three-dimensional flow. Pressure distribution load carrying capacity friction forces in oil film and coefficient of friction in journal bearing. Solid lubricants types and applications

Bearing Design

Design of bearing, Clearance in journal bearing, minimum film thickness, sommar-field number, oil grooves and flow of oil in axial and circumferential grooves cavitations and turbulence in oil bearings. Heat generation and cooling or bearing hydrostatic and dynamic and their applications in machine tools. Design of air bearing ad other gas bearing

Rolling friction 12

Reynolds's slip, heath cote concept selection of roller bearings and their methods of lubrication design aspects and modes of bearing failures and also hydrodynamic lubrication

Solid Lubricants

Solid lubricants and its applications in metal forming processes.

Recommended Books:

Title	***Author(s)***	***Publisher***
Fundamentals of Tribology	R Gohar and H Rahnejat	World Scientific
Engineering Tribology	*Gwidon W. Stachowiak and Andrew W. Batchelor*	Elsevier
A Machine Design Handbook	Powell	McGraw Hill
A text book of Machine Design	Sharma and Aggarwal	Kataria
Standard handbook of machine design	Shigley, Mischke and Brown	McGraw Hill

Subject Code : MET 825 C (Elective-II)
Title of the course : Tool and Die Design

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:

After successful completion of course, the students should be able to

CO1: Understand the different types of metal cutting operations and cutting parameters used in turning, drilling and milling operations.

CO2: Understand the different types of tool nomenclature systems (ASA, NRS, ORS) for a single point cutting tool.

CO3: Select different cutting tool materials based on desired properties.

CO4: Design fixtures for milling, boring, lathe, grinding, welding.

CO5: Explain the principles of dies and moulds design.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	S	S		M						S
CO2	M	M	S	S		M						S
CO3	M	M	S	S		M						S
CO4	M	M	S	S		M						S
CO5	M	M	S	S		M						S

Theory:

SECTION-I 12

Classification of cutting tools: Various machining operations and the tools required to carry out these operations: principle elements of various cutting tools; geometry of single point cutting tool geometry in ASA, ISO, ORS & NRS systems.

Tool Materials: Properties of cutting tool materials, development of cutting tool materials, composition, production process and application of different cutting tool materials viz. High carbon steel, HSS, carbides, Ceramics, CBN, UCON, zirconia tungten alumina, PDC and diamond tools.

Design of Form and Single point cutting tools 12

Cutting parameters of a lathe, different turning operations and cutting tools used for these operations. Classification of single point cutting tools: solid, carbide tipped tools, geometrical parameters of a single point cutting tool, design procedure of single point cutting tool, re-sharpening of single point cutting tools. Types of form tools, design procedure and their sharpening, industrial applications.

Die Design

Classification of dies, die materials, production process, die design procedure for open and closed dies. Example and applications

SECTION-II

Design of Double and Multi Point Tools 12

Types of drills, solid, carbide tipped drills, drill geometry, geometrical parameters of a twist drill, design procedure of a twist drill, re-sharpening of the twist drill.

Milling Cutter Design

Milling operations, milling cutting parameters, different milling operations and cutting tools for these operations. Types of milling cutters, solid, and carbide tipped cutter; geometrical parameters of a milling cutter, design procedure of a disc type milling cutter, re-sharpening of the cutters.

Broach design 12

Broaching operation and its advantages, broaching cutting parameters, types of broaches, solid, and carbide tipped broaches; design procedure of a broach, re-sharpening of the broach.

Hob design

Gear nomenclature, construction of involutes profile, hobbing operation and its advantages, geometrical parameters of a hob, design procedure of a hob.

Recommended Books:

Title	***Author(s)***	***Publisher***
Tool Design	Donaldson	McGraw Hill
Cutting tools	Prakash Joshi	Wheeler Publishing
Metal Cutting theory & practice	Arschinow & Alearoev	Mir publication

Subject Code : MET 825 D (Elective-II)
Title of the course : Control Systems in Manufacturing

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to
CO1: Carry out the modelling of physical systems using Bond Graphs.
CO2: Carry out the simulations of dynamics using MATLAB.
CO3: Design and analysis of control system for linear and non-linear systems.
CO4: Design and analysis in state-space method.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S							M
CO2	S	S	S	S	S							M
CO3	S	S	S	S	S							M
CO4	S	S	S	S	S							M

Theory:

SECTION-I

Introduction Definition, classification, examples, closed loop and open loop control systems, The laplace transform and its applications in control system. 12

Mathematical Modelling of Dynamic systems Transfer function and impulse response function, block diagrams, signal flow graph, state-space representation

Transient response analysis of first order and second order systems

Time domain analysis and design Root locus method, Routh stability criteria, effect of poles and zeros on system performance. Basic requirement in designing of time domain analysis. Applications through case study. 12

SECTION-II

Frequency domain analysis and design Bode plot, Nyquist stability criteria, Lag , lead compensation Design elements of frequency domain. 12

Analysis and design in state-space method Controllability and obervability, pole placement method, examples of control system design using MATLAB,case study. 12

Recommended Books:Title	**Author(s)**	**Publisher**
Modern Control Engineering	K. Ogata	PHI
Automatic Control Systems	B.C. Kuo	PHI
Control System Engineering	Nise	Wiley
Modern Control Systems	Dorf and Bishop	Pearson Education
Modern Control System Theory	M. Gopal	New Age International

Subject Code : MET 825 E (Elective-II)
Title of the course : Measurement and Industrial Instrumentation

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:

After successful completion of course, the students should be able to

CO1: Understand the standard measurement practices in system analysis and quality control in a legal and ethical way.

CO2: Understand the basic principle of sensing in measurement of physical quantities and automation of instruments.

CO3: Understand the basics of micron and submicron level measurements by mechanical and optical methods and latest developments.

CO4: Develop sustainable measurement systems for shop floor.

CO5: Handle various measuring instruments and collect noise free data.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	M	S		M	M	S				S
CO2	S	S	M	S		M						S
CO3	S	M	M	S	S	M						M
CO4	M	M	S	S		M	S					M
CO5	M	M	M	S		M			M			M

Theory: SECTION I

Introduction to Measurement and Process Control Introduction, Standard of Measurements, Definition of Process Control, Elements of a Process Control System, Requirements Intuitive Approach to Process Control Concepts. 07

Process Control Loops Introduction, Single-loop Feedback Control, Time Elements of a Feedback Loop, Comparison of Basic Physical Systems, Dead Time Lag, Advanced Control Loops, Tuning Control Loops. 05

Precision Dimension measurement Optical flats, application of monochromatic light & optical flats, use of optical flats & monochromatic light for dimensional comparison, interferometer. 04

Pressure measurement and control Manometers, pressure gauges, level measurement and control, Sight-type Instruments, Pressure-type Instruments, Electrical-type Instruments, Sonic-type

Instruments, Radiation-type Instruments, Level Switches. 04

Surface Roughness Height Measurement Surface roughness, R_a, R_t/R_z, definition, various methods to measure surface roughness, different instruments for measuring surface roughness, roughness standard. 04

SECTION II

Rotation measurement Introduction, use of counters, stroboscope, direct application of frequency standard by comparative methods. Tachometers: types- mechanical, electrical, frequency tachometer. calibration of frequency sources. 06

Strain Measurements Mechanical strain gauges, optical strain gauges, electrical strain gauges, variable resistance strain gauge, sensing element materials, forms of strain gauge sensing elements, strain gauge adhesive, protective coating, strain gauge mounting techniques, strain graphs. 06

Force & Torque measurement Introduction, measuring methods, load cell, piezo type load cell, hydraulic & pneumatic system, torque measurement, dynamometer, classification, type & characteristics. Industrial applications. 06

Temperature measurement Reference Temperatures, Thermometers, Thermocouples, Resistance Temperature Detectors, Thermistors, Integrated-Circuit Temperature Sensors, Radiation Pyrometers, their working and temperature measuring principles. 03

Vibration Measurement Introduction, various methods, acquisition and processing of vibration signals, vibration measuring equipments and principle of measurement. 03

Recommended Books:Title	**Author(s)**	**Publisher**
Instrumentation for Engg. Measurement	J.W. Dally, R.F. William and Mc Connell	John Wiley and Sons
Measurement Systems, Application & Design	E. O. Doebelin	TMH
Mechanical Measurements	T. G. Beckwith, L.N. Buck and R. D. Marangoi	Addison Wesley Reading
Instrumentation, Measurement & Analysis	Nakra & Chaudhary	TMH

Subject Code : MET 911
Title of the course : Advanced Metal Forming

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to:

CO1: Apply the theories of yield criterion to the metal forming process.
CO2: Analyze the metal forming process due to tensile deformation using analytical methods.
CO3: Analyze the metal forming process due to compressive deformation using analytical methods.
CO4: Analyze the deformation of the metal and rolls under roll forming process.
CO5: Apply the numerical methods to analyze the simplified metal forming processes.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S										M
CO2	S	S										M
CO3	S	S	M									M
CO4	S	S										M
CO5	S	S	S									M

Theory:

SECTION-I

Introduction: Stress-strain relations in elastic and plastic deformations, Plastic Deformation and Yield Criteria for ductile metals; Isotropic (von-Mises and Tresca's criterion); Anisotropic (Hill's Criterion 1948 and Barlat's 2005), hardening postulate (Isotropic hardening only). Flow curve and different mathematical relations, simple solving methods for metal forming problems; Slab method, Upper and Lower bound methods; Slip line field theory. Effect of temperature and effect of strain rate in metal working

Drawing: Drawing of a flat strip and round bar, determination of drawing load, drawing with wedge shaped dies, cylindrical dies, and cylindrical rod drawing with a conical die. Analysis of the processes and maximum possible reduction

Tube making: Introduction, plug drawing with a conical die, calculation of drawing forces and load, tandem drawing of tubes on a mandrel, tube sinking, concept of tube production by rolling and extrusion methods

Deep Drawing: Introduction, Analysis for circular cup drawing using various materials, defects in deep drawing and their remedial actions.

SECTION-II

Extrusion: Introduction, round bar extrusion through a conical die, flat strip extrusion through dies of constant angles, impact extrusion, and hot extrusion of steels, case: calculation of forces ; Al- strip drawing/extrusion.

Rolling: Rolling of flat slabs and strip: Cold rolling and hot rolling, roll-pressure determination, rolling with no external tensions, rolling with front and back tensions, and applications of lubricants, defects and remedies.

Forging: Forging: Introduction, determination of plain strain compression load, weight friction condition, inclined platen, thin strip, load evaluation for forging a flat circular disc

Frictions lubrication: Friction and lubrication in metal working, introduction, influences of friction in metalworking processes, lubricants used for different metalworking processes

Unconventional Forming: Introduction to unconventional forming processes like hydrostatic extrusion, hydro-forming of sheets and tubes, powder forming, electro-hydro forming

Introduction to Finite element methods: Introduction, simple finite elements and its shape functions (Truss, Beam, Quadrilateral, Hexahedral and Trapezoidal elements), Introduction to Stiffness matrix and Force vector (Point forces, Body forces) generation, Introduction to assembly of elemental stiffness matrix to global stiffness matrix (All concepts are for introduction only)

Recommended Books: Title	**Author(s)**	**Publisher**
Principles of Industrial Metal working Processes.	G. W. Rowe	CBS
Manufacturing Science	Ghosh & Malik	East West
Foundry, Forming and Welding	P.N. Rao	TMH
Modelling Techniques for Metal Forming Processes	G. K. Lal, P. M. Dixit, N. V. Reddy	Narosa Publication

Subject Code : MET 912 B (Elective-III)

Title of the course : Product Design & Development

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to

CO1: Understand the prerequisites of the product design & development, concept of product life cycle, including PLM framework, product data management, system integration and quality issues.
CO2: Apply the concept of value engineering and value analysis to product design & development.
CO3: Understand the underlying issues on material and process selection for product design & development.
CO4: Apply the concept of design for manufacture and assembly, incorporating other life cycle issues at the design stage.
CO5: Understand the principles of engineering ethics and liability issues; and apply the basic tools of design protection.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	M								S
CO2	S	S	S	M								S
CO3	S			M								S
CO4	S	S		M								S
CO5				M		S		S				S

Theory:

SECTION I

Stages in Design process: Introduction to various stages of the design process: Indentify Customer Needs, Establish target specifications, Generate and Test Product concept, Final Specifications, Product architecture, Industrial Design, Case study.
Product life cycle: New product introduction: early introduction, increased product life. Product Lifecycle Management: Product information, PLM framework, Enabling technologies, Product

data management (PDM) , Functions of PDM software. System integration, QFD, House of quality, Case studies.

Value engineering: Introduction, nature and measurement of value, Value analysis job plan, Creativity and techniques of creativity, Value analysis test, Case studies

Concurrent/ reverse engineering: Introduction, basic principles, components, benefits of concurrent engineering. Concept of reverse engineering. 24

SECTION II

Material selection: Materials in design, The evolution of engineering materials, Design tools and material data, Function, material, shape and process, Material selection strategy, attribute limits, selection process, COMPOSITECOMPOSITE
material selection, Case studies

Process selection: Introduction, Process classification: shaping, joining and finishing, Systematic process selection, Ranking, process cost, Computer – aided process selection.

Design for manufacture and assembly: Design for Manufacture and Assembly (DFMA), Reasons for non- implementation, Advantages, Design for Manufacture in relation to any two manufacturing processes: machining and injection molding, Need, objectives.

Design for 'X': Introduction, Design for: Safety, quality, reliability, energy conservation, environment, ergonomics, maintenance, recyclability and disposal.

Patents, liability and ethics: Introduction, Protecting your design: patents, copyright, basic tools of design protection. Liability issues in product design. Ethical considerations, Examples/ case studies

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Recommended Books: Title	**Author(s)**	**Publisher**
Product Design & Development	Karl T. Ulrich, Steven D. Eppinger	Mc GrawHill
Integrated Product and Process Development	John M. Usher, Utpal Roy and H. R. Parasaei	Tata McGraw Hill
Product Design for Manufacture and Assembly	G. Boothroyd, P. Dewhurst and W. Knight	Marcel Dekker
Product Design and Manufacture	A. K. Chitale and R. C. Gupta	PHI
Selection of Materials and Manufacturing Processes for Engineering Design	Mahmoud M. Farag	Printice Hall
Material Selection in Mechanical Design	M. F. Ashby	Elsevier
Concurrent Engineering	Biren Prasad	Prentice Hall

Subject Code : MET 912 C
Title of the course : Manufacturing System Analysis

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:

After successful completion of course, the students should be able to

CO1: Understand System Components, system structure; system inputs and outputs and apply the knowledge to problem definition.

CO2: Model formulation, functional and equipment structuring. Linear graph approach. Time models.

CO3: Analyze the dynamic analysis of organization; total flow of man, information and materials; and application to practical organisation

CO4: Formulate and optimise the Optimization of system performance using appropriate techniques.

CO5: Understand the System Design Elements; Game and decision theory and its applications.

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	M		S						S
CO2	S	S	S									S
CO3	S	S	S						S			S
CO4	S	S	S	M							S	S
CO5	S	S	S	M							S	S

Theory:

SECTION-I

System Components 12

The environment and the system concept; system structure; system inputs and outputs; system approach to macro problems; problem definition with system concepts and approach.

System Modeling

Model formulation; Representation of dynamics signal and system flow graph; System interactions; System compatibility; Sub-systems and inter-connections; Functional and equipment structuring. Linear graph approach. Time models.

System Simulation 12

Basic philosophy of simulation; Analog and Digital Computers; System with feedback. Continuous and Discrete system simulation.

SECTION-II

System Dynamics 12

Dynamic analysis of systems; Dynamic behavior of organization; Total flow of man, information and materials; Dynamic analysis of the models for capital equipment and orders; Derivation of the policies for management based on system models.

Optimization 12

Optimization of system performance; Perturbation analysis of system parameters; Criteria for optimization, Gradient method; Dynamic programming method.

System Design

Elements of Decision analysis; Game theory; Application of game and decision theory to system design. Techniques for creative design; Elementary sensitivity analysis.

Recommended Books:

Title	***Author(s)***	***Publisher***
System Engg. Tools	Chestnut,	John Wiley
Design of Engg. Systems	Gosling	John Wiley
System Engg.,	A.D.Hall	Van Nostrand, U.K.
System Engg. Handbook	Machol,	McGraw Hill Inc
Introduction to System Science	G.M.Sandquist	Prentice-Hall
System Modeling and Analysis	Nagrath & Gopal	Tata McGraw Hill
System Simulation	Geoffrey Gordon	Prentice Hall of India
Industrial Dynamics	Forester	MIT Press
Concepts of Engineering System Design	Warren E. Wilson	McGraw Hill,
Realtime System Design and Analysis	P. A. Laplante,	Prentice Hall of India
System Design & Analysis,	Avadh	Galgotia Publishers

Subject Code : MET 912 D (Elective-III)
Title of the course : ROBOTICS

L	T	P	Credits	Weekly Load
3	1	0	4	4

Course Outcomes:
After successful completion of course, the students should be able to:

CO1: Understand the basic concepts of industrial robotics in terms of classification, kinematics, sensors, and typical applications.
CO2: Understand the control techniques used for rehabilitation robots.
CO3: Understand the knowledge on advanced algebraic tools for the description of motion.
CO4: Design and implement control applications for autonomous mobile robots.
CO5: Understand the dynamics of the manipulator**.**

Pre-requisite knowledge:

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S		S							S
CO2	S	S	S									M
CO3	S											S
CO4	S		S		S	S				S		S
CO5	S	S			S	S						S

Theory:
SECTION-I

Introduction 12
Evolution of robot and robotics, laws of robotics, robot anatomy: Links, joints, Degrees of freedom (DOF), Arm configuration, wrist configuration, end-effector

Coordinate Frame, Mapping and Transforms Coordinate frames, description of objects in space, transformation of vectors, inverting a homogeneous transform, fundamental rotation matrices

Kinematics 12

Denavit- Hartenberg Notation, kinematic relationship between adjacent links, Manipulator transformation matrix, Inverse kinematics

Linear and angular velocity of a rigid body, velocity propagation along links, manipulator jacobian.

SECTION-II

Dynamics Lagrange-Euler Formulation, Newton-Euler Formulation 12

Control of manipulators Position control, Force control: Applications of standard control strategies. 12

Recommended Books:Title	**Author(s)**	**Publisher**
Robotics and Control	Mittal and Nagrath	TMH
Introduction to Robotics	J.J. Craig	Pearson Education
Vector mechanics	Beer and Johnston	TMH
Control System Engineering	Nise	Wiley
Simulation Modeling & Analysis	David Kelton	Tata McGraw Hill