COCHIN UNIVERSITY OF SCIENCE & TECHNOLOGY

Minutes of the Board of Studies of Mechanical and Marine Engineering held on 03.05.2021, at 2.00 pm in the ONLINE MODE

Members Present

1. Prof. Dr.Radhakrishna Panicker M. R :Chairman, BoS
2. Prof.Dr. Saju KK : Member
3. Prof.Dr. Gireeshkumaran Thampi B. S. :Member
4. Prof.Dr. James Varghese :Member
5. Prof.Dr. Simon K. A. : Member
6. Prof. John M. P. : Member
7. Prof. Roy V. Paul : Member
8. Prof.Dr. Senthil Prakash M.N : Member

Agenda:

1. Revised syllabus of M. Tech(PT) in Mechanical Engineering with specialization Production Engineering w.e.f 2021 onwards
2. Any other item permitted by chair

Decisions:

The Chairman welcomed all members and the following decisions were taken.
1. The meeting approved the scheme and syllabus for the revised syllabus of M. Tech (PT) in Mechanical Engineering with specialization Production Engineering w.e.f 2021 onwards
2. Since there was no other item, the meeting was concluded at 3 pm

Prof.Dr. Radhakrishna Panicker M. R.
Chairman, BoS.

M.Tech. (PT) Degree Course

in

MECHANICAL ENGINEERING
(Specialization: Production Engineering)

SCHOOL OF ENGINEERING
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COCHIN – 682 022

2021

Scheme and Syllabus of M. Tech Degree Course (PT) in Mechanical Engineering (Specialization: Production Engineering)

SEMESTER I

Course Code	Subject	Credit
MEP3101	Applied Mathematics	3
MEP3102	Advanced Materials and Processes	3
MEP3103	Metal Forming Theory	3
MEP3104	Maintenance and Reliability Engineering	3
MEP3105	Seminar	1
Total		13

SEMESTER II

Course Code	Subject	Credit
MEP3201	Additive Manufacturing	3
MEP3202	Advanced Computer Integrated Manufacturing	3
MEP3203	Computational Methods in Engineering	3
MEP3204	Elective I	3
MEP3205	Computational Methods Laboratory	1
Total		13

SEMESTER III

Course Code	Subject	Credit
MEP3301	Finite Element Method and Applications	3
MEP3302	Mechanical Behaviour of Materials	3
MEP3303	Modern Machining Processes	3
MEP3304	Elective II	3
MEP3305	CAD/CAM Laboratory	1
Total		13

SEMESTER IV

Course Code	Subject	Credit
MEP3401	Computer Numerical Control of Machine Tools	3
MEP3402	Elective III	3
MEP3403	Elective IV	3
MEP3404	Project – Phase I	2
Total		11

SEMESTER V

Course Code	Subject	Credit

MEP3501	Project – Phase II	11
Total		11

SEMESTER VI

Course Code	Subject	Credit
MEP3601	Project – Phase III	11
Total		11

Total credits for the programme = 13 +13 +13+11+11+11 = 72

Electives

Course code	**Subject**	**No of credits**
E1	Mechatronics	**3**
E2	Nano Technology and Surface Engineering	**3**
E3	Six Sigma	**3**
E4	Process Control and Automation	**3**
E5	Machine Learning and AI	**3**
E6	Bio Materials	**3**
E7	Material Behaviour at High Temperatures	**3**
E8	Industrial Tribology	**3**
E9	Hydraulic and Pneumatic Drives	**3**
E10	Mechanical Vibrations	**3**
E11	Special Purpose Machine Tools	**3**
E12	Quality Engineering and Management	**3**
E13	Logistics and Supply Chain Management	**3**
E14	Engineering Optimization	**3**

MEP 3101 APPLIED MATHEMATICS

Course Outcomes:

On successful completion of the course, the student will be able to:

1. Identify sampling and different sampling distributions
2. Evaluate inference about difference in means and variances
3. Explain analysis of variance and determining sample size
4. Apply various types of designs of experiments
5. Apply factorial designs for statistically designed experiments
6. Identify multiple linear regression analysis
7. Examine model diagnostics

Module I

Simple Comparative Experiments: Basic statistical concepts – sampling and sampling distributions – Inference about difference in means, randomized – Inference about the difference in means, paired comparison designs – inferences about the variance of normal distributions.

Module II

Experiments with a single factor: Analysis of Variance – analysis of fixed effects model – model adequacy checking – practical interpretation of results – determining sample size – discovering dispersion effects – regression approach to analysis of variance

Module III

Randomized Blocks, Latin Squares and Related Designs: Randomized Complete Block Design (RCBD) – Latin Square Design – Graeco- Latin Square Design – Balanced Incomplete Block Designs (BIBD). **Factorial Design**: Two-factor factorial design – general factorial design – fitting response curves and surfaces – blocking and confounding in factorial design – 2^k factorial design

Module IV

Fitting regression models: Linear regressions models – estimation of parameters in linear regression models – hypothesis testing in multiple regression – confidence interval in multiple regression – predictions of new response observations – regression model diagnostics – testing for lack of fit

References

1. Montgomery D.C - Design and Analysis of Experiments, John Wiley &Sons Inc
2. Freedman D , Pisani R and Purves R - Statistics, WW Norton & Company

MEP 3102 ADVANCED MATERIALS AND PROCESSES

Course Outcomes:

On successful completion of the course, the student will be able to:

1. *Summarize and classify the structural and functional materials including various alloys, superalloys, and ceramic composites.*
2. *Understand the mechanisms and transformations of shape memory alloys.*
3. *Elaborate on nanomaterials- classification, properties, and applications.*
4. *Describe different material characterization techniques including macroscopic and microscopic testing.*

Module I

Introduction, Demand of advanced materials, design principles. Structural Materials: Porous matrix ceramics- composites, Metallic foam, Cellular Materials, Nano tubes, Nano wires. Mechanically alloyed oxide dispersion strengthened superalloys, High strength and ductile bulk quasi crystalline alloys and their composites. High temperature materials: Iron, nickel and cobalt base super alloys, Gamma- Titanium aluminades Thermal barrier coating for aero engines and gas turbines.

Module II

Functional Materials: Classification, size effect on structural and functional properties, Processing and properties of Glassy and nanocrystalline materials. Thin films and multi-layered coatings, single- walled and multi-walled carbon nanotubes; soft and hard magnetic materials for storage devices. Low dielectric constant materials, optoelectronic materials, Piezoelectric Materials

Module III

Smart Materials: Shape memory alloys, hydrogen storage alloys, Functionally gradient material (FGM).Mechanisms of one-way and two-way Shape Memory Effect, Reverse Transformation, Thermoelasticity and Pseudo elasticity, Examples and applications Bulk Metallic glasses: Criteria for glass formation and stability, Examples and mechanical behavior

Module IV

Processing: Single Crystal Growth, Rapid Solidification, Inert Gas Condensation, Physical and Chemical Vapor Deposition of Thin Films. Processing of Ni- base superalloys for turbine engine discs,. Introduction to Material Characterization Techniques: Macroscopic testing, Microscopy and Spectroscopy Techniques: XRD, SEM TEM, XPS

References

1. Callister: Material Science and Engineering, Wiley, 2014
2. Kenneth G Budinski: –Surface engineering for wear resistance, Prentice Hall, 1988.
3. D.R. Gabe: Principles of metal surface treatment and protection, Pergamon Press, 1978.
4. Dieter: Engineering design, A materials and processing approach (III Edition), McGraw Hill, 1999.
5. Rama Rao, P: Advances in Materials and their applications, Wiley Eastern Ltd.
6. Bhushan, B: Nano Technology, Springer.
7. S.O Pillai: Solid State Physics, New Age International, 7th edn, 2006
8. Straughan and Walker, Spectroscopy – Vols. I & II, Chapman & Hall
9. Serope Kalpakjian and Steven R. Schmid: Manufacturing processes for Engineering Materials, Prentice Hall 2003.

MEP 3103 METAL FORMING THEORY

Course Outcomes:

On successful completion of the course, the student will be able to:

1. *Review the theory of elasticity, the principal stress and strain concepts, stress and strain transformations, and tensors.*
2. *Analyze the state of stress and strain using Mohr's circle and explain generalized Hooke's law.*
3. *Understand the different yield criteria for metals, plasticity theory, and various stress-strain relations.*
4. *Explain the capabilities and applications of different metal forming processes and the related analyses.*
5. *Elaborate on slip lines and related theories, and bound theorems with proof.*

Module I

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

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.

Module III

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

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

MEP 3104 MAINTENANCE AND RELIABILITY ENGINEERING

Course outcomes:

On successful completion of the course, the student will be able to:

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1. *Explain the basic concepts of maintenance- need, objectives, types, related costs, and benefits.*
2. *Describe the different types of maintenance- breakdown, preventive, diagnostic, design out, and opportunity.*
3. *Interpret the different error detection and monitoring methods, signature, and lubricant analysis.*
4. *Summarize the concepts of reliability- elements, measures, design for reliability, and testing.*

Module I

Maintenance management - Need for maintenance – Objective – Concepts – Types of maintenance – Organization – Trade force mix- type and location – Maintenance costs – Benefits – Computer aided maintenance management – Total productive maintenance – Concepts- Maintainability and availability concepts, two unit parallel system with repair; Preventive maintenance, k-out-of-m systems

Module II

Types of maintenance - Breakdown and preventive maintenance – Advantages and limitations – Maintenance prevention – Diagnostic maintenance – Design out maintenance – Opportunity maintenance. Diagnostic maintenance - Leak detection – Wear monitoring – Temperature monitoring – Vibration monitoring – Signature analysis – Shock monitoring – Lubricant analysis – Methodology – equipment - Applications.

Module III

Concepts of reliability -Elements of probability – Reliability definition – Measures of reliability – Failures – Classification of failures – Failure data analysis – Availability – Criticality matrix – Event tree analysis – Utilization factor – Factors affecting reliability. Analysis of reliability data – weibull analysis - Design and manufacture for reliability – Reliability of parts and components – Design for system reliability – Economics of standby or redundancy in a production system – Reliability testing – Types.

Module IV

System reliability models: Systems with components in series, system with parallel components, k-out of-m systems, non-series-parallel systems, system with mixed mode failures, fault tree techniques; Redundancy techniques in system design: Component versus unit redundancy, mixed redundancy, standby redundancy, redundancy optimization, double failures and redundancy

References

1. Higgins & Morrow: Maintenance engineering handbook, Tata McGraw-Hill, 1985.
2. Collact: Mechanical fault diagnosis and condition monitoring", McGraw-Hill, 1985.
3. Miller & Blood: Modern maintenance management, Tarapoorwala& Sons, 1976.
4. Jentry E J & Kumamoto H:Reliability engineering and test assessment, Prentice Hall, 1992.
5. Carter A D S: Mechanical reliability, Macmillan, 1984.
6. Nakajima S, Introduction to TPM", Total Productivity Maintenance Productivity Press 1995.
7. O' Connor P D T, "Practical reliability engineering", John Wiley 1994.
8. E Balagurusamy, Reliability Engineering, McGraw Hill Education India P Ltd, 17th Reprint, 2017
9. L.S Srinath, Reliability Engineering, East West Press, 4th Edition, 2005, Reprint 2016

CEP 3105 Seminar

Course Outcomes:

On successful completion of the course, the student will be able to:

1. Identify the current research trends/needs in any specific area of Mechanical Engineering
2. Gather relevant information on the specific topic
3. Document the collected information in a specified format
4. Present the collected information and face an audience with confidence

Students shall individually prepare and submit a seminar report on a topic of current relevance related to the field of Mechanical Engineering. The reference shall include standard journals, conference proceedings, reputed magazines and text books, technical reports and URLs (minimum 10 references published in the last 5 years). A committee consisting of at least two faculty members shall assess the presentation of the seminar and award marks to the students.

MEP3201 ADDITIVE MANUFACTURING

Course outcomes:

. *On successful completion of the course, the student will be able to:*

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1. *Explain the basic concepts and principles of rapid manufacturing technologies.*
2. *Select a suitable rapid prototyping process for a given application.*
3. *Describe the different types of direct and indirect rapid tooling techniques with the principle of working, advantages, and applications.*
4. *Elaborate on laser sintering and 3D printing operations with future scope and applications.*
5. *Understand the basics of different data extraction and processing techniques.*

Module I

Product Developing Cycle, Additive Manufacturing, Definition of Rapid Product Development, Virtual prototypical and rapid manufacturing technologies, Physical Prototyping & rapid manufacturing technologies, Synergic integration technologies**.** Principle of Rapid Prototyping, Various RP technologies, Selection of a suitable RP process for a given application, Status of outstanding issue in RP- accuracy, speed, materials (strength, homogeneity and isotropy), Emerging Trends.

Module II

Rapid Tooling: Introduction to Rapid Tooling, Indirect Rapid Tooling, Silicon rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling, Direct Rapid Tooling Classification: Liquid based system, Stereolithography Apparatus (SLA), details of SL process, products, Advantages, Limitations, Applications and Uses. Solid based system – Fused Deposition Modeling, principle, process, products, advantages, applications and uses – Laminated Object Manufacturing.

Module III

Selective Laser Sintering – principles of SLS process, principle of sinter bonding process, Laser sintering materials, products, advantages, limitations, applications and uses. Three Dimensional Printing – process, major applications, research and development. Direct shell production casting – key strengths, process, applications and uses, case studies, research and development. Laser Sintering System, e-manufacturing using Laser sintering, customized plastic parts, customized metal parts, e-manufacturing – Laser Engineered Net Shaping (LENS).

Module IV

Data Extraction, Data Processing, Applications and Case Studies: Engineering Applications, Medical Applications, Processing of Polyhedral Data: Polyhedral BRep modeling, Introduction to STL format, Defects and repair of STL files, Overview of the algorithms required for RP&T and Reverse Engineering, Laboratory and demonstration sessions.

References:

1. Rafiq I. Noorani, *Rapid Prototyping - Principles and Applications*, Wiley & Sons, 2005.

2. C. K. Chua, K. F. Leong and C. S. Lim, *Rapid Prototyping: Principles and Applications*, 3rd ed., World Scientific, 2010.

3. N. Hopkinson, R. J. M. Hauge, and P. M. Dickens, *Rapid Manufacturing – An Industrial revolution for the digital age*, Wiley, 2006.

4. Ian Gibson, *Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping*, Wiley, 2006.

5. Paul F. Jacobs, *Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography*, McGraw Hill, 1993.

6. D. T. Pham, and S. S. Dimov, *Rapid Manufacturing*, Springer Verlog, 2001.

MEP3202 ADVANCED COMPUTER INTEGRATED MANUFACTURING

Course outcomes:

On successful completion of the course, the student will be able to:

.

1. *Illustrate different manufacturing operations and models.*
2. *Define the basics of group technology, process planning, and cellular manufacturing.*
3. *Analyze the process and material handling capabilities using computer-aided process planning techniques.*
4. *Classify storage and propose different flexible manufacturing systems.*
5. *Explain the fundamentals of NC technologies and the advanced methods to execute them.*

Module I

Manufacturing operations: Product/production relationships, Manufacturing models and metrics; Elements of automation system, Concurrent engineering, Components of a Manufacturing system, Classification scheme for manufacturing systems, Analysis of single station systems. Group Technology and process planning: Part families, Part classification and coding, Cellular manufacturing, Quantitative analysis in cellular manufacturing, Process planning, Process engineering, Experiment based planning.

Module II

Process capability analysis: Introduction to Computer aided process planning, Variant process planning, Generative process planning. Material handling: Shop floor control Analysis of material transport system, Analysis of vehicle based system, Conveyor analysis.

Module III

Storage systems: Storage system performance, storage location strategies. Automated storage systems: ASRS, Carousel storage systems. Automatic Identification and Data capture: Bar codes and RFID. Flexible manufacturing systems: Components, Material handling and storage system, Computer control system, Quantitative analysis, Shop floor control and simulation. NC, CNC, DNC & CIM and Data base control systems:

Module IV

Computer Aided Process Planning: Retrieval CAPP Systems, Generative CAPP Systems, Feature Identification- Algorithms, Graph Based Approach, Attribute Adjacency Graph, Benefits of CAPP. Integrated process planning systems: Totally integrated process planning systems – an overview - modulus structure – data structure, operation - report generation, expert process planning.

References

1. M. P. Groover, *Automation, Production Systems and Computer Integrated Manufacturing*, 4th Edn. Pearson Education 2016.
2. J. A. Rehg and H. W. Kraebber, *Computer Integrated Manufacturing*, Pearson, 2004.
3. M. B. Zaremba and B. Prasad, *Modern Manufacturing: Information Control and Technology (Advanced Manufacturing)* Springer 2011.
4. S. K. Vajpayee, *Principles of Computer Integrated Manufacturing*, Prentice Hall India, 2003.
5. Gideon Halevi and Roland D. Weill, "Principles of process planning - a logical approach", Chapman & Hall, 2012
6. Tien-Chien Chang, Richard A.Wysk, "An introduction to automated process planning systems", Prentice Hall, 1985
7. Chang, T. C., "An expert process planning system", Prentice Hall, 1985
8. Nanua Singh, "Systems approach to computer integrated design and manufacturing", John Wiley & Sons, 1996
9. Zude Zhou, Huaiqing Wang, Ping Lou, "Manufacturing Intelligence for Industrial Engineering: Methods for System Self-Organization, Learning, and Adaptation", Engineering Science Reference, 2010.
10. Andrew Kusiak, Intelligent Manufacturing System, Prentice Hall Inc., New Jersey, 1992

MEP3203 COMPUTATIONAL METHODS IN ENGINEERING

Course outcomes:

On successful completion of the course, the student will be able to:

1. *Apply various CAS programs to solve numerical problems including linear algebraic equations, iterations, vector calculations, etc.*
2. *Find solutions by application of different interpolation methods and transform techniques.*
3. *Compute differential, Laplace, and Poisson's equations to find numerical solutions.*
4. *Understand calculus of variations and apply finite element theory in various field problems*

Module I

Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation. Solution to linear algebraic equations: Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss – Siedel), convergence criteria, Pivoting strategies, Operation Count, Matrix inversion, Special cases -Tridiagonal systems - Block tridiagonal systems, Well conditioned and Ill conditioned system , Matrix and Vector norms, Condition Number and its implications.

Module II

Solution to Non-linear Algebraic Equations :Bisection, Newton-Raphson, and Secant method , System of non-linear equations Interpolation methods: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials, Differentiation and Integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration.

Module III

Finite difference method :Discretization of spatial and time derivatives using Taylor's series (b) Truncation error and order of discretization (c) Fourier (von Neumann) accuracy analysis Solution to Ordinary Differential Equations (a) Initial Value problems-Euler explicit and implicit methods, Runge-Kutta method, Predictor-Corrector methods, (b) Boundary value problem - Shooting method

Module IV

Solution to Partial Differential Equations : Classification of PDEs and characteristics of a PDE, Solution to Elliptic Partial Differential Equations - Physical problems governed by elliptic , Five-point and nine-point discretization of Poisson's equation, Iterative methods - Jacobi, Gauss-Seidel, and SOR, Steepest Descent and Conjugate Gradient, Solution to Parabolic Partial Differential Equations -Physical problems governed by parabolic PDE's , Operator splitting and ADI methods (Introduction to CAS programs like Matlab/Scilab/Mathematica/Maple/Python and their application to solve numerical examples of the topics included above).

References

1. Steven C Chapra, Applied Numerical Method with Matlab for Engineers and Scientists, McGraw-Hill, 2017.
2. Schilling R.J and Harris S. L, Applied Numerical Methods for Engineering using Matlab and C, Brooks/Cole Publishing Co., 2003.
3. S. S. Sastry, Introduction to Numerical Methods, Prentice-Hall, 1999.
4. Numerical methods for scientists and engineers – J. Hoffman and S. Frankel, CRC Press
5. Numerical Mathematics and Computing – W. Cheney and D. Kincaid, International Thomson Publishing Company
6. Applied Numerical Analysis – C. Gerald and P. Wheatley, Addison-Wesley
7. Analysis of Numerical Methods – E. Isaacson and H. B. Keller, John Wiley & Sons

MEP 3204- ELECTIVE

MEP 3205 COMPUTATIONAL METHODS LABORATORY

Course Outcomes:

On completion of this course a student will be able to

1. Demonstrate the programming concepts of C
2. Develop computer programming skills
3. Apply the computer programming skills in developing C program for various numerical methods
4. Analyze the numerical results based on computer programming

(C – Programming)

Numerical solutions of algebraic and transcendental equations:

1. Bolzano's bisection method
2. method of false position
3. Newton Raphson method.

Solutions to linear algebraic equations:

4. Gauss elimination method
5. Gauss Jordan method
6. method of triangular decomposition
7. Gauss Seidal iteration method

Numerical differentiation:

8. using Newton's forward interpolation formula
9. Newton's backward interpolation formula
10. Stirlings formula

Numerical Integration:

11. Newton –cotes quadrature formula
12. Gauss quadrature formula
13. Double integrals

References

1. Veerarajan T and Ramachandran T, numerical methods with programs in C, Tata McGraw Hill Publishing Company Limited.
2. Venkateshmurthy MG, Programming techniques through C, Pearson Education

MEP3301 FINITE ELEMENT METHOD AND APPLICATIONS

Course outcomes:

On successful completion of the course, the student will be able to:

.

1. *Solve one-dimensional problems by the application of finite element analysis.*
2. *Apply the methods of finite element analysis in fluid mechanics and heat transfer areas.*
3. *Assess various elasticity problems and solve them using the finite element analysis method.*
4. *Formulate eigenvalue problems and analyze finite element errors*

Module I

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

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 III

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 IV

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

MEP3302 MECHANICAL BEHAVIOUR OF MATERIALS

Course outcomes:

On successful completion of the course, the student will be able to:

1. *Analyze the strength of materials using stress-strain relationships for structural and thermal loading.*
2. *Determine the stresses, strains, and displacements of structures by tensorial and graphical (Mohr's circle) approaches.*
3. *Determine the deformation of structures subjected to various loading conditions using strain energy methods.*
4. *Determine the characteristics of fatigue failure and understand the methods to improve fatigue strength.*
5. *Explain creep, related mechanisms, and variables affecting creep.*

Module-I

Strength of materials- basic assumptions, elastic and plastic behaviour, stress–strain relationship for elastic behaviour, elements of plastic deformation of metallic materials. Mohr's circle, yielding theories Elements of theory of plasticity, dislocation theory properties of dislocation

Module-II

Stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening Ductile and brittle fracture, Charpy and Izod testing, significance of DBTT, ECT, NDT and FATT; elements of fractography.

Module-III

Griffith's theory, LEFM– COD and J integral – determination of KIC, COD and J integral Characteristics of fatigue failure, initiation and propagation of fatigue cracks, factors affecting fatigue strength and methods of improving fatigue behavior.

Module-IV

Testing analysis of fatigue data, mechanics of fatigue crack propagation, principle of corrosion, corrosion fatigue Introduction to creep - creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter - Manson Hafred parameter.

References:

1. Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill, 1988
2. Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979.
3. Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials', Volume III, 4th Edition, John Wiley, 1984

MEP3303 MODERN MACHINING PROCESSES

.Course outcomes:

On successful completion of the course, the student will be able to:

1. *Understand the significance and importance of non-conventional machining in the current and future scenario.*
2. *Explain the most relevant advanced machining processes like EDM and ECM.*
3. *Analyze the different process parameters for better performance in machining.*
4. *Explore modern processes like ultrasonic machining, abrasive jet machining, plasma arc machining, electron beam machining, laser beam machining etc.*
5. *Conduct a comparative evaluation of the different modern machining processes*.

Module I

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

Module II

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. Comparison of MRR and Comparison of Process parameters.

Module III

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 IV

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.

MEP3304 ELECTIVE II

MEP3305 CAD/CAM LABORATORY

Course outcomes:

On successful completion of the course, the student will be able to:

1. *Prepare a CNC program and execute it on a CNC milling machine.*
2. *Prepare a CNC program and execute it on a CNC lathe.*
3. *Achieve geometrical and dimensional accuracy using co-ordinate measuring machine.*
4. *Program an IR52 Robot using manual teaching method and textual language programming.*
5. *Design and analysis using CAD/CAM packages like IDEAS & ANSYS.*

1. **CNC Milling Machine**

Manual and computer aided CNC programming for milling and drilling.

2. **CNC Lathe**

Manual and computer aided CNC programming for turning.

3. **CMM**

Geometrical and dimensional metrology using co-ordinate measuring machine

4. **IR52C Robot**

Programming of IR52 Robot using manual teaching method and textual language programming (PSI Robo programming language)

5. **CAD/CAM Packages IDEAS & ANSYS**

Design and analysis using CAD/CAM packages like IDEAS & ANSYS

MEP 3401 COMPUTER NUMERICAL CONTROL OF MACHINE TOOLS

Course outcomes:

On successful completion of the course, the student will be able to:

1. *Elaborate on CNC machines and know the configuration and interfacing of the system.*
2. *Develop a CNC program and knowledge of various programming techniques and software.*
3. *Describe tooling for CNC machines- systems, requirements, assemblies, and management.*
4. *Explain special types of CNC machines, EDM, punch press, etc., and evaluate the CNC machines.*

Module I

Basic concepts of CNC machines - Introduction - Classification - Construction details of CNC machine structure, guide ways, feed drives, spindle, measuring systems Drivers and controls Spindle drives, feed drives. D.C drives - A.C drives. Introduction - Configuration of CNC system -Interfacing - Monitoring - Diagnostics – Machine data - compensations for machine accuracies – PLC programming - DNC - Adaptive control CNC systems.

Module II

Programming of CNC machines - Various programming techniques APT programming for various machines in ISO and FANUC CAM packages for CNC machines - IDEAS, Unigraphics, CATIA, ESPIRIT etc.

Module III

Tooling for CNC machines -Interchangeable tooling systems - Preset and qualified tools - coolant fed tooling systems - Modular fixturing - Quick change tooling system - Automatic head changers Tooling requirements for turning and machining centers Tool holders Tool assemblies – Tool magazines - ATC mechanisms - Tool management..

Module IV

Special types of CNC machines -CNC grinding machines, EDM, Wire cut EDM, Punch press - Installation, Maintenance - Testing and Performance, Evaluation of CNC machines. Computer process control, Numerical control, Fundamentals of NC technology, Application of NC - CNC, machine control of CNC- DNC, Just-in-time manufacturing systems, Internet Enabled Manufacturing, Virtual Manufacturing, and e-maintenance.

References

1 RADHAKRISHNAN P. "Computer numerical control machines". New Central Book Agency, 1996.
2. SEHRAWAT M S & NARANG JS, "CNC machines" Dhanpat Rai and Co., 1999.
3. "Mechatronics", HMT Limited, Tata McGraw Hill Publishing Company Ltd., 1998.
4. THYER GE."Computer numerical control of machine tools" B H Newberg 1991.

5. M. P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, 4th Edn. Pearson Education 2016.
6. J. A. Rehg and H. W. Kraebber, Computer Integrated Manufacturing, Pearson, 2004.
7. M. B. Zaremba and B. Prasad, Modern Manufacturing: Information Control and Technology (Advanced Manufacturing) Springer 2011.
8. S. K. Vajpayee, Principles of Computer Integrated Manufacturing, Prentice Hall India, 2003.

MEP3402 ELECTIVE III

MEP3403 ELECTIVE IV

MEP3404 PROJECT – PHASE I

Course Outcomes:

On completion of this course, the student will be able to:

1. *Identify topics in thrust areas in Mechanical Engineering, making use of the technical and engineering knowledge gained from previous courses, with the awareness of its usefulness to society/ industry.*
2. *Review relevant literature on the chosen topic.*
3. *Plan and schedule the independent research work on the topic by experimental/ analytical approaches.*

Each student shall identify a project related to the curriculum of study. At the end of the semester, each student shall submit a project synopsis comprising of the Literature survey (minimum 15 journal paper published in the last 10 years), Description of newness in the identified Problem, Aim and Objectives, Practical relevance or application of the data generated in the work.

The evaluation shall be done by a team of Head of the Division/expert faculty nominated by head of the Division, Project Guide, and the Coordinator.

MEP 3501 Project – Phase II

Course Outcomes

On completion of this course, the students will be able to:

1. *Document and present the results of the part of the project work completed in a professional way*
2. *Communicate technical information by means of oral as well as written presentation skills with professionalism.*
3. *Defend the findings of the research before the evaluation committee.*

At the end of the semester, each student shall submit a project interim report comprising of Literature Review, Aim and Objectives, Research methodology and data generated in the work.

The evaluation of the progress shall be done by a team of Head of the Division/ faculty expert nominated by head of the Division, Project Guide, and Co-Ordinator.

MEP 3601 Project -Phase III

Course Outcomes:

On completion of the project work, students will be able to

1. *Demonstrate a degree of analysis and a degree of originality in advanced investigations*
2. *Document and present the results of research work in a professional way*
3. *Communicate technical information by means of oral as well as written presentation skills with professionalism and engage in life-long learning*
4. *Defend the findings of the research before an expert panel*
5. *Take up any challenging practical problems and find better solutions*

At the end of the semester, each student shall submit a detailed project report comprising of Introduction, Literature survey (minimum 15 journal paper published in the last 10 years), Description of newness in the identified Problem, Aim and Objectives, Practical relevance or application of the data, Research methodology, data generated in the work, Results and Discussion, Conclusion and scope of future research.

The project dissertation shall be presented before the examination committee consisting of Head of the Division/faculty expert nominated by the head of the Division, Project Guide, coordinator and an External expert.

ELECTIVES

E1- MECHATRONICS

Course outcomes:

On completion of this course, the students will be able to:

1. *Summarize the concepts of mechatronics- elements, design process, types and advanced approaches.*
2. *Define actuators, transducers, sensors and their different types.*
3. *Explain various types of controllers, signals, and microprocessors.*
4. *Apply fuzzy logic, artificial intelligence and micro sensors in mechatronics.*

Module I

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

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

Signals, System & Controllers: Introduction to Signals, system and Controls-System representation-Linearization-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

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. DevadasShetty, 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.

E2 - NANO TECHNOLOGY AND SURFACE ENGINEERING

Course outcomes:

On completion of this course, the students will be able to:

1. *Understand the concept, characterization, advantages and limitations of nano materials.*
2. *Get introduced to nano composites, it's processing and applications.*
3. *Elaborate on tribology and surface engineering.*
4. *Define various advanced surface deposition and spraying techniques.*

Module-I

Concept of nano materials – scale / dimensional aspects, Top-down and bottom-up approaches for preparing nano materials - Advantages and limitations at the nano level – thermodynamic aspects at the nano level, health and environmental issues. Characterization of nano materials and nano structures, important characterization techniques for nano size measurement.

Module-II

Overview of properties of nano materials, Introduction to nano composites, processing of nanocomposites. Applications in different areas such as semi conductors, sensors, nanostructured bioceramics and nanomaterials for drug delivery applications.

Module-III

Introduction tribology, surface degradation, wear and corrosion, types of wear, roles of friction and lubrication- overview of different forms of corrosion, introduction to surface engineering, importance of substrate Chemical and electrochemical polishing, significance, specific examples, chemical conversion coatings, phosphating, chromating, chemical colouring, anodizing of aluminium alloys, thermochemical processes -industrial practices Surface pre-treatment, deposition of copper, zinc, nickel and chromium - principles and practices, alloy plating, electrocomposite plating, electroless plating of copper, nickelphosphorous, nickel-boron; electroless composite plating; application areas, properties, test standards (ASTM) for assessment of quality deposits.

Module- IV

Definitions and concepts, physical vapour deposition (PVD), evaporation, sputtering, ionplating, plasma nitriding, process capabilities, chemical vapour deposition (CVD), metal organic CVD, plasma assisted CVD, specific industrial applications Thermal spraying, techniques, advanced spraying techniques - plasma surfacing, D-Gun and high velocity oxy-fuel processes, laser surface alloying and cladding, specific industrial applications, tests for assessment of wear and corrosion behaviour.

TEXT BOOKS

1. Pradeep T "Nano: The Essentials", Mc Graw Hill Publishing Co. Ltd., 2007
2. Mick Wilson et al, "Nanotechnology", Overseas Press (India) Pvt. Ltd., 2005.
3. Charles P. Poole, Jr., Frank J. Owens, "Introduction to nano technology", Wiley, 2003.
4. Gunter Schmid, "Nanoparticles: From Theory to Applications", Wiley-VCH Verlag GmbH & Co., 2004
5. Sudarshan T S, 'Surface modification technologies - An Engineer's guide', Marcel Dekker, Newyork, 1989
6. Varghese C.D, 'Electroplating and Other Surface Treatments - A Practical Guide', TMH, 1993

E3 - SIX SIGMA

Course outcomes:

On completion of this course, the students will be able to:

1. *Summarize the concepts of six sigma, phase and probability.*
2. *Construct control charts and analyse the process performance.*
3. *Analyse, compare, visualize and correlate data.*
4. *Plan and design experiments using different techniques including response surface methodology.*

5. *Understand the basics on lean six sigma, Project Management and Financial Analysis*

Module I

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

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

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

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 Strategy Revolutionizing the World’s Top Corporations, New York – Doubleday, 2000.

E- 4 PROCESS CONTROL AND AUTOMATION

Course outcomes:

On completion of this course, the students will be able to:

1. *Define automation- strategies, elements, functions and levels.*
2. *Categorize industrial control systems and analyse production flow.*
3. *Derive forward and Inverse kinematic equations for various types of Robots.*
4. *Get introduced to manipulators and it’s applications.*

Module I

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

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

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

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.

E5 - MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE

Course outcomes:

On completion of this course, the students will be able to:

1. *Relate machine learning and statistics*
2. *Apply algorithms in machine learning.*

3. *Explain clustering and dimensionality reduction.*
4. *Elaborate on artificial intelligence systems and cognition.*
5. *Define automation- strategies, elements, functions and levels.*
6. *Get introduced to different AI techniques.*

Module I

Relation between Machine Learning and Statistics. Introduction to Algorithms in Machine Learning – Classification, Supervised machine learning – linear regression, Multiple linear regression, Logistic regression – Model representation, Discriminant Analysis, Classification Trees, Support Vector Machine.

Module II

Introduction to unsupervised learning - Clustering – types of clustering, Dimensionality Reduction, Principal Component Analysis algorithm, Factor analysis.

Module III

Era of Intelligent Systems - The Fourth Industrial Revolution Impact, The Technology of the Fourth Industrial Revolution, Introduction to Artificial Intelligence and Cognition.

Module IV

Application of artificial intelligence (AI) techniques: Meta-heuristics: Genetic Algorithm, Scatter Search, Tabu Search, Particle Swarm Intelligence, Ant Colony Optimization; Artificial Neural Networks; Fuzzy Logic Systems; Case based reasoning.

References

1. J.F. Hair, W.C. Black, B. J. Babin, and R.E. Anderson, *Multivariate Data Analysis*. 7thEdn. Pearson New International, 2015.
2. T. Hastie, R. Tibshirani, J. Friedman, *The elements of statistical learning*. 2nd Edn. New York: Springer, 2017.
3. E. Rich, K. Knight, S. B. Nair, *Multivariate Data Analysis*. 3rd Edn. Pearson New International, 2012.
4. M. Gardener, *Beginning R: The statistical programming language*. Wiley India Publication, 2012.
5. R.A. Johnson, and D.W. Wichern, *Applied Multivariate Statistical Analysis*. 6thEdn. Pearson New International, 2015.
6. J.S. Hurwitz, M. Kaufman, and A. Bowles, *Cognitive Computing and Big Data Analytics*, Wiley 2005.
7. M. Skilton, and F. Hovsepian, *The 4th Industrial Revolution*, Palgrave Macmillan, 2017.

E6- BIOMATERIALS

Course outcomes:

On completion of this course, the students will be able to:

1. *Explain the significance, applications and evaluation of bio materials.*
2. *Get introduced to nanomaterials and nanocomposites for medical applications.*
3. *Describe the concept of biocompatibility and it's related assessment studies.*
4. *Summarize the advanced applications of bio materials in the medical field.*

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Module-I

Introduction to biomaterials; need for biomaterials; Salient properties of important material classes; Property requirement of biomaterials; Metallic implant materials, ceramic implant materials, polymeric implant materials, composites as biomaterials; Orthopedic, dental and other applications.

Module-II

Biomaterials preparation and characterization; Processing and properties of different bioceramic materials; Mechanical and physical properties evaluation of biomaterials; New and novel materials for biomedical applications. Design concept of developing new materials for bio-implant applications; Nanomaterials and nanocomposites for medical applications;

Module-III

Concept of biocompatibility; cell-material interactions and foreign body response; assessment of biocompatibility of biomaterials; *In-vitro* and *In-vivo* evaluation; Dissolution study, cytotoxicity test, cell adhesion test; Antibacterial assessment: Kirby–Bauer disc diffusion method or antibiotic sensitivity test and spread plate method.

Module-IV

Biomaterials for drug delivery, timed release materials; biodegradable polymers; Blood compatible materials; Biomimetics; Bone biology: bone architecture, collagen, osteoblasts, osteoclasts, etc; Protein mediated cell adhesion; Introduction to tissue engineering; Applications of tissue engineering; Biomaterials world wide market, technology transfer and ethical issues; Standards for biomaterials and devices.

References

1. Hench L. Larry, and Jones J., (Editors), Biomaterials, Artificial organs and Tissue Engineering, Woodhead Publishing Limited, 2005.

2. Hench L. Larry, & Wilson J., (Editors), An Introduction to Bioceramics, World Scientific, 1994.

E7- MATERIAL BEHAVIOUR AT HIGH TEMPERTAURES

Course outcomes:

On completion of this course, the students will be able to:

1. *Study the factors influencing functional life of components at elevated temperatures.*
2. *Define and differentiate ductile and brittle fracture.*
3. *Understand the oxidation process and the methods to control it.*
4. *Explain the significance of Iron base, nickel base and cobalt base superalloys.*
5. *Making and shaping of superalloys for high temperature applications*

Module - 1

Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate. Design of transient creep time, hardening, strain hardening, expressions of rupture life of creep, ductile and brittle materials, Monkman-Grant relationship. Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage fracture, ductile fracture due to micro void coalescence-diffusion controlled void growth; fracture maps for different alloys and oxides.

Module-2

Oxidation, Pilling, Bedworth ratio, kinetic laws of oxidation- defect structure and control of oxidation by alloy additions, hot gas corrosion deposit, modified hot gas corrosion, fluxing mechanisms, effect of alloying elements on hot corrosion, interaction of hot corrosion and creep, High temperature corrosion of carbon steels, alloy steels , stainless steels and super alloys. Methods to combat hot corrosion. Protection coatings. Metal dusting corrosion of metals and alloys- Introduction and background, nature of the metal dusting environment, metal dusting of pure metals, metal dusting of alloys, control of metal dusting.

Module-3

Elevated temperature mechanical properties of Carbon and alloy steels, Chromium steels, Cr-Mo-V steels, hot work tool and die steel, maraging steels, short and long term elevated temperature tests, tempered martensite embrittlement, creep embrittlement, creep fatigue interaction. Stainless steels and their high temperature properties, thermally induced embrittlement. High temperature properties of non- ferrous heat resistant materials- Titanium and its alloys, coatings. Refractory metals and alloys- Molybdenum, tungsten, Niobium, Tantalum, Rhenium alloys, their elevated temperature properties and applications. Nickel-chromium and Nickel- Thoria alloys,

Module-4

Making and shaping of super alloys for high temperature applications- Melting and conversion- solidification of super alloys, EAF, VIM, VAR, ESR. Ingot conversion and mill products. Investment castings. Forging and forming. Powder metallurgy of super alloys. Heat treating. Joining techniques. composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase, embrittlement, solidification of single crystals,. Single crystals and turbine blades.Trade names and uses of most common super alloys. Intermetallics, high temperature ceramics

References

1. Raj. R., “Flow and Fracture at Elevated Temperatures”, American Society for Metals, USA, 1985.
2. Hertzberg R. W., “Deformation and Fracture Mechanics of Engineering materials”, 4th Edition, JohnWiley,USA,1996.
3. Courtney T.H, “Mechanical Behavior of Materials”, McGraw-Hill, USA, 1990.
4. Heat Resistant Materials- ASM Speciality Hand book- ASM International, Ohio.
5.Deformation and Fracture Mechanics of Engineering materials- Hertzberg R.W, 4th Edition, John Wiley, USA, 1996.
6. Mechanical Behaviour of Materials- Courtney T .H McGraw-Hill, USA, 1990.
7. Superalloys- A technical guide-Mathew J. Donachie, Stephen J. Donachie, ASM International, Ohio, 2002.

E- 8 INDUSTRIAL TRIBOLOGY

Course outcomes:

On completion of this course, the students will be able to:

1. *Derive basic equations and identify the applications of bearings.*
2. *Design and analyse various bearings.*
3. *Assess different surface interactions, topography and friction of metals.*
4. *Elaborate on wear, corrosion and fatigue on metals, ceramics and composite materials.*

Module I

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

Module II

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

Module III

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 IV

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

E- 9 HYDRAULIC AND PNEUMATIC DRIVES

Course outcomes:

On completion of this course, the students will be able to:

1. *Describe the applications of oil hydraulics and pneumatics in pumps and motors.*
2. *Analyse various valves used to control flow in hydraulic and pneumatic systems.*
3. *Elaborate on electro hydraulic servo mechanisms and configurations of hydraulic power supplies.*
4. *Understand the Components of a pneumatic system.*

Module I

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

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

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

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, McGraw-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. lanMeneal, Hydraulic operation and control of Machine tools – Ronald Press
11. Stewart, Hydraulic and Pneumatic power for production – Industrial press

E- 10 MECHANICAL VIBRATIONS

Course outcomes:

On completion of this course, the students will be able to:

1. *Describe vibrations under different conditions.*
2. *Explain multi degree freedom systems and formulate matrix.*
3. *Analyse vibratory systems using various approximate methods.*
4. *List out and explain methods to measure vibrations.*

Module I

Introduction: Free vibrations, Response of single degree of freedom system, Viscous damping, Under damped, Critically damped and Over damped vibrations, Forced vibrations, Support excited motion, Rotating Unbalance, Vibration isolation, Coulomb damping, Self excitation and Stability analysis.

ModuleII

Multi degree freedom systems: Two and three degrees of freedom spring mass systems, Semidefinite systems, Matrix formulation, Eigen value problems, Mode shapes, Coordinate Coupling, Lagrange's equations. Influence coefficients, Torsional vibratory systems, Location of Nodes, Torsionally equivalent shaft, Two rotor system, Three rotor system, Geared system.

Module III

Approximate methods to analyse vibratory system: Rayleigh's energy method, Dunkerleys method. Vibration of continuous systems: exact methods, boundary value problem, Eigen value problem, Axial vibration of a bar or rod, Wave equation, Transverse vibration of beams, Boundary conditions, Transverse vibration of shafts, Whirling speed of shafts.

Module IV

Vibration measurement and applications: Transducers, Variable resistance, Piezoelectric, LVDT, Vibration pickups, Vibrometer, Accelerometer, Velometer, Phase distortion, Frequency measuring instruments, Vibration exciters, Signal analysis, Machine conditioning monitoring and diagnosis, Vibration severity criteria, Vibration monitoring techniques, Instrumentation systems.

References

1. S. S. Rao, Mechanical Vibrations, Pearson education, 2004.
2. W. T. Thomson, Theory of Vibrations with applications, CRC Press, 1996.
3. Benson H Tongue, Principles of Vibration, Oxford University Press, 2002.
4. AAShabana, Theory of Vibration – An Introduction, Springer Intl Edition, 1995.
5. T.D Rossing& N.H Flectcher, Principles of Vibration and Sound, Springer, 1976.
6. Ambekar, Mechanical Vibrations and Noise Engineering, PHI, 2006.
7. William W Seto, Theory and Problems of Mechanical Vibrations, Schaum's Series, 1964.
8. J P Den Hartog, Mechanical Vibrations, Dover Publications, 1985.

E-11 SPECIAL PURPOSE MACHINE TOOLS

Couse outcomes:

On completion of this course, the students will be able to:

1. *Summarize automation production systems and demonstrate an auto lathe.*
2. *Classify automatic loading and feeding devices.*
3. *Select appropriate transfer machines.*
4. *Describe the concepts of modular design and unit heads for machine tool*

Module I

Introduction to automation - Automation production system - Features of fixed automation and programmable automation - Reasons for automating - Socio economic relevance of automation. Classification - Cam mechanisms used in automats - General layout and features of Auto lathe - Automatic screw machine sliding head automatic lathe, multi- spindle automatics - Mechanisms - Bar feeding mechanisms - Tool layout for automation- Principles of design of cam for automats.

Module II

Automatic loading and feeding devices - Classification - Types of magazines feeding and hopper feeding devices - Escapements and feeders - Devise for orientation - Vibratory bowl feeders.

Module III

Transfer machines - Introduction - Merits and limitations - Product design for transfer machine - Selection of transfer devices - Types of automatic transfer machine - main features of automatic transfer machines - In line, rotary indexing table and drum type machines

Module IV

Automatic loading and transferring machines -Inspection and tool servicing in transfer lines – transfer press - Linked lines - Concept of Modular design and unit head - modular design and unit heads for machine tool.

References

1. M P GROOVER, “Automation production systems and computer integrated manufacturing” Prentice Hall Inc., New Jersey 1980.
2. B L BOGUSLAVSKY “ Automatic and semiautomatic lathes”, Peace Publishers Moscow
3. H C TOWN, “ Automatic machine tools”, Life Books Ltd., London, 1968.
4. SEN & BHATTACHARYA, “ Principles of machine tool”, New Central Book Agency,1975.
5. HASLE & HUREST, “Manufacturing technology”, Hodder and Stoughton, Great Britain, 1981.

E-12 QUALITY ENGINEERING AND MANAGEMENT

Course outcomes:

On completion of this course, the student will be able to

1. *Understand the concept of quality and leadership.*
2. *Elaborate on the contributions of various quality gurus and quality tools.*
3. *Explain on QFD and product designs and to analyze the failure modes and effects.*
4. *Prepare control charts and understand the concepts of statistical process control.*
5. *Apply different techniques of acceptance sampling and selection of proper sampling procedures*

Module I

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

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

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

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.

E- 13 LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Course outcomes:

On completion of this course, the student will be able to

1. *Understand the structures, decision phases, measures and tools of supply chains.*
2. *Understand the strategic, tactical and operational decision tools of supply chains.*
3. *Understand knowledge on logistics management and related advanced tools and techniques.*

Module I

Introduction to Supply Chain Management (SCM):Concept of Logistics Management, Concept of supply management and SCM, Core competency, Value chain, Elements of supply chain efficiency, Flow in supply chains, Key issues in supply chain management, Decision phases in supply chain, Supply chain integration, Process view of a supply chain, Competitive Strategy and supply chain strategies, Uncertainties in supply chain, Supply chain drivers.

Module II

Sourcing and Procurement: Outsourcing benefit, Importance of suppliers, Evaluating a potential supplier, Supply contracts, Competitive bidding and Negotiation, E-procurement Purchasing: Objectives, Relations with other departments, Centralised and Decentralised purchasing, Purchasing procedure, Types of orders, Tender buying, Purchasing department records, Computer based systems/EDI. Stores Management: Functions, Storage methods, Receiving, Inspection, Issues, Inventory Valuation.

Module III

Introduction to Inventory Management: Selective Control Techniques, MUSIC-3D systems, Various costs. Independent Demand Systems: Deterministic Models, Quantity Discounts - all units, incremental price; Sensitivity, Make-or-buy decisions. Multi-item Joint Replenishment: Economic Production Quantity for multiple items. Inventory System Constraints: Exchange Curve (Optimal Policy Curve), Working Capital restrictions, Storage Space restrictions.

Module IV

Independent Demand Systems (Probabilistic Models): Single order Quantities: Payoff Matrix, Expected Value Criterion, Lost sales case, Mathematical formulation of discrete and continuous cases. Dynamic Order Quantities: Q- system, P- system, Mathematical modelling under known stock out costs and service levels, Managing inventory in supply chain: Bullwhip effect, Information and supply chain trade-offs

References

1. Chopra, S., and Meindl, P., Supply chain Management: Strategy, Planning and Operations. Second Edition, Pearson Education (Singapore) Pte. Ltd, 2004.
2. Simchi-Levi, D., Kaminsky, P., and Simchi-Levi, E., Designing & Managing the Supply Chain: Concepts, Strategies & Case studies. Second Edition, Tata McGraw-Hill Edition, 2003.
3. Doebler, D.W. and Burt, D.N., Purchsing and Supply Chain Management: Text and Cases, McGraw-Hill Publishing Company Limited, New Delhi, 1996.

E-14 ENGINEERING OPTIMIZATION

Course outcomes:

On completion of this course, the student will be able to

1. *Understand the engineering applications of optimization and state an optimization problem.*
2. *Classify optimization techniques considering constraints.*
3. *Solve linear programming, transportation and assignment problems.*
4. *Describe non-linear programming and formulate problems.*
5. *Get introduced to integer programming and related methods.*

Module I

Introduction to Optimization: Engineering applications of optimization; Statement of an optimization problem; Classification of optimization problems. Classical Optimization Techniques: Single variable optimization, with equality Constraints, Solution by the method of Lagrange multipliers, multivariable optimization with inequality constraints Kuhn – Tucker condition.

Module II

Linear Programming- Simplex method – Duality- Transportation and assignment problems. Non-Linear Programming (NLP): One-Dimensional Unconstrained Optimization – Single variable optimization; Fibonacci method; Golden-section method. Interpolation Method**:** Quadratic and Cubic Nonlinear programming (Unrestricted Optimization Technique) Random search methods, Univariate method, Simplex method. Descent Methods**:** Steepest descent, conjugate gradient, variable metric method.

Module III

Non-Linear Programming (NLP): Constrained Optimization – Problem formulation; Necessary and sufficient conditions for optimality. Frank Wolfe Method. Dynamic Programming : -Multistage decision process -Concept of sub optimization and Principle of optimality.

Module IV

Introduction To Integer Programming**-** Gomory's cutting plane method, branch and bound method-first variation, problems with integral constraints Non-traditional Optimization Algorithm- Genetic algorithm- Working principle, GA Operators, Introduction to Simulated Annealing, Artificial Neural Networks

References

1. G. V. Reklaitis, A. Ravindran & K. M. Rajsdell, 'Engineering Optimization - Methods and Applications', John Wiley & Sons, 2007
2. Singiresu S. Rao, 'Engineering Optimization Theory and Practices', John Wiley and Sons,3rd Edition, 2009
3. A. Ravindran, Don T. Philips and Jamer J. Solberg, 'Operations Research - Principles and Practice', John Wiley & Sons, 2007
4. P. G. Gill, W. Murray and M. H. Wright, 'Practical Optimization', Academic Press, 1981
5. Fredrick S. Hiller and G. J. Liberman, 'Introduction to Operations Research', McGraw-Hill Inc, 2002
6. Ashok D. Belegundu, Tirupathi R. Chandrapatla, 'Optimization Concepts and Applications in Engineering', Pearson Education, Delhi, 2014.