COURSE STRUCTURE AND SYLLABI OF M. Tech. PROGRAMME

in

RELIABILITY ENGINEERING

(An Interdisciplinary Course)

(From Academic Year 2015-16)

Board of Studies meeting during 25th & 26th April 2015

Department of Electrical Engineering
JNTUA College of Engineering (Autonomous)

INFORMATION ON THE COURSE

1.0 Details about the Course.

1.1 Name of the Course (s)

Name of Degree/ Diploma	Name of Specialization	Intake (Full/Part time) to be started	Year of Starting	Duration (Total)	Name of Degree & Branch eligible for admission
M. Tech.	Reliability Engineering	18 Regular + 07 Sponsored	2009	2 Years	Any Branch B. Tech/B. E

1.2 Course Structure and scheme of evaluation (Semester-wise)

Name of the Subject	Hrs./Week			Evaluation (Marks)		
	L	P	C	Internal	External	Total
I-SEMESTER						
1. 15D24101 System Reliability Concepts	4	-	4	40	60	100
2.15D24102 Life Testing & Reliability	4	-	4	40	60	100
Estimation	4	-	4	40	60	100
3. 15D24103 Statistical Quality Control	4	-	4	40	60	100
4. 15D24104 Stochastic Processes						
5.Elective-I	4	-	4	40	60	100
15D24105 Software Reliability	4	-	4	40	60	100
15D24106 Reliability in Engineering Design						
6. Elective-II	4	-	4	40	60	100
15D24107 Information Security	4	-	4	40	60	100
15D22102 Advanced Digital Signal Processing						
RE Any other Elective Subject offered by any other Engineering Department with prior permission from Chairman BoS, and CAC of the college	-	4	2	40	60	100
7. 15D24108 Reliability Tools Lab						
II-SEMESTER						
1. 15D24201 Six Sigma Concepts	4	-	4	40	60	100
2. 15D24202 Risk Assessment and Management	4	-	4	40	60	100
3. 15D24203 Maintenance Engg & Management	4	-	4	40	60	100
4. 15D24204 Reliable & Fault Tolerant Computing	4	-	4	40	60	100
5. Elective-I						
15D24205 Reliability Optimization	4	-	4	40	60	100
15D24206 Monte Carlo Simulation	4	-	4	40	60	100
6. Elective-II						
15D21201 Power System Reliability	4	-	4	40	60	100
15D22203 Intelligent Algorithms	4	-	4	40	60	100
RE Any other Elective Subject offered by any other Engineering Department with prior permission from Chairman BoS, and CAC of the college						
7. 15D54201 Research Methodology(Audit Course)						
8. 15D24207 Reliability Testing Lab	2	-	0			
	-	4	2	40	60	100
III SEMESTER	**T**	**P**	**C**			
15D24301 Seminar - I	-	4	2			
IV SEMESTER	**T**	**P**	**C**			
15D24401 Seminar - II	-	4	2			
III & IV SEMESTERS						
15D24302 Project Work	-	-	44			

15D24101 SYSTEM RELIABILITY CONCEPTS

UNIT-I: Basic Probability Theory
Basic concepts – Rules for combining Probabilities of events – Failure Density and Distribution functions – Bernoulli’s trials – Binomial distribution – Expected value and standard deviation for binomial distribution – Examples.

UNIT-II: Network Modeling and Reliability Evaluation
Basic concepts – Evaluation of network Reliability / Unreliability – Series systems, Parallel systems, Series - Parallel systems, partially redundant systems – Types of redundancies - Evaluation of network Reliability / Unreliability using conditional probability method – Paths based and Cutset based approach – complete event tree and reduced event tree methods - Examples.

UNIT-III: Time Dependent Probability
Basic concepts – Reliability functions f(t), F(t), R(t), h(t) – Relationship between these functions – Baths tubs curve – Exponential failure density and distribution functions - Expected value and standard deviation of Exponential distribution – Measures of reliability – MTTF, MTTR, MTBF – Evaluation of network reliability / Unreliability of simple Series, Parallel, Series-Parallel systems - Partially redundant systems - Evaluation of reliability measure – MTTF for series and parallel systems – Examples.

UNIT-IV: Discrete Markov Chains & Continuous Markov Processes
Basic concepts – Stochastic transitional Probability matrix – time dependent probability evaluation – Limiting State Probability evaluation – Absorbing states – Markov Processes-Modelling concepts – State space diagrams – time dependent reliability evaluation of single component repairable model – Evaluation of Limiting State Probabilities of one, two component repairable models – Frequency and duration concepts – Frequency balance approach - Examples.

UNIT-V: Multi Component & Approximate System Reliability Evaluation
Recursive relation for evaluation of equivalent transitional rates, cumulative probability and cumulative frequency and ‘n’ component repairable model - Series systems, Parallel systems, Basic reliability indices – Cutset approach – Examples.

Text Book:

1. System Reliability Concepts by V. Sankar, Himalaya Publishing House, 2015.

Reference Books:

1. Reliability Evaluation of Engineering Systems by Roy Billinton and Ronald N. Allan, Reprinted in India B. S. Publications, 2007.
2. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill, 2003.
3. Reliability and Maintainability Engineering by Charles E. Ebeling, Tata McGraw Hill, 2000.
4. Probability concepts in Electric Power system – G.J.Anders- 1st edition –1990 – John wiley & sons.

15D24102 LIFE TESTING & RELIABILITY ESTIMATION

UNIT-I

Probability Distribution Functions - Discrete distributions - Uniform distribution, Marginal Distribution, Negative binomial distribution and Geometric distribution. Continuous distribution - Exponential distribution, double exponential, Rayleigh distribution, Weibull distribution, Gamma distribution, Beta distribution, Pareto distribution, Normal distribution and lognormal distribution - Sampling distribution - Correlation – The concept of Correlation, measuring correlation - Auto and cross correlation functions – Properties.

UNIT-II

Interval Estimation - Unbiased Estimators, Interval Estimates (Confidence Intervals), Prediction Intervals, Central Limit Theorem, Parametric Bootstrap Estimation - Parameter estimation - Unbiased estimators - Point estimators - Properties of point estimators - Maximum likelyhood estimation - Bayes estimation - Mean Square estimation - Linear mean square estimation - Examples.

UNIT-III Reliability Life Testing Methods

Reliability Life Testing - Test time calculations, Burn-in testing, Acceptance testing, accelerated life testing and Experimental Design - Reliability Growth Testing - Growth process, Idealized growth curve and other growth modals. Goodness of Fit tests - Chi-square goodness of fit test, Bartlett’s test for the exponential distribution, Mann’s test for the weibull distribution, kolmogorov smirnov test for normal and lognormal distributions and tests for the power law process model.

UNIT-IV

Baye’s testing and Testing Hypotheses - Terminology in Statistical Tests of Hypotheses, Hypothesis Tests: Means, Hypothesis Tests: Proportions, Hypothesis Tests for Difference between Two Means: Small Samples - Known, Hypothesis Test with Paired Samples, Hypothesis Tests: Variances, Hypothesis Tests for Independence, Homogenity, and Goodness of Fit.

UNIT- V

Non-Parametric Methods - Introduction, The Sign Test, Nonparametric Bootstrap Estimation, The Sign Test for Paired Data, The Wilcoxon Signed - Rank Test, Wilcoxon – Mann -Whitney (WMW) Rank Test for Two Samples, Spearman Rank Order Correlation Coefficient, Kendall’s Rank Correlation Coefficient (t), Nonparametric Tests for Regression, Nonparametric Tests for ANOVA, Runs Test and Randomization Tests.

Reference Books:

1. E Balagurusamy, Reliability Engineering, Tata McGraw-Hill.
2. S. K. Sinha, Reliability and Life Testing, Wiley Eastern Ltd., 1986.
3. Charles E. Ebeling, Reliability and Maintainability Engineering, Tata McGraw-Hill.
4. Ronald Deep, Probability and Statistics, Elsevier Publishers.

15D24103 STATISTICAL QUALITY CONTROL

UNIT-I: QUALITY CONTROL

Quality, quality control, factors affecting quality, methods of control, chance causes and assignable causes. Quality control and Quality assurance, Quality Costs, Organization for quality, Quality circles, and Statistical process control.

UNIT-II: CONTROL CHARTS

Statistical process control –Control charts for variables and attributes. Process and machine capabilities. 6 sigma concept.

UNIT-III: ACCEPTANCE SAMPLING:

Types of sampling, sampling inspection, inspection by Attributes and Variables, Role of acceptance sampling , Procedure for sampling inspection, single, double, multiple sequential sampling plans, O.C. Curves, quality indices for acceptance sampling plans , acceptance sampling by attributes, AQL , LTPD , AOQL – Sampling plans.

UNIT-IV: TOTAL QUALITY MANAGEMENT

Quality management system, Definition of TQM, Principles of TQM, Organizational structure of TQM, Total quality control, Total employee involvement, Bench marking –Principles and Procedures, ISO9000 and quality management system. ISO9000 series, quality audits.

UNIT-V: TOOLS AND TECHNIQUES FOR TQM

Ishikawa diagrams, Pareto diagrams, Histograms, Scatter diagrams, Process Flow Diagram, Check Sheet, Stratification, Quality Function Deployment- House of quality, procedure to carry out QFD, Failure Mode and Effects Analysis, Fault tree analysis, Poka-Yoke, Continuous Process Improvement – Kaizen, PDCA Cycle. House Keeping – 5S principles.

REFERENCE BOOKS

1. Jain K.C. & Chitale. A.K., Quality Assurance and TQM- Khanna Publisher, 1998.
2. Sharma S.C., Inspection, Quality control and Reliability- Khanna Publishers, 1998.
3. Srinath L.S., Reliability Engineering – Affiliated East West Press, 1975.
4. Juran.J.M. & Frank.M.Gryna - Quality Planning and Analysis TMH, 1995.
5. Egene L., Grant and Others, Statistical Quality Control – McGraw Hill, 1988.

15D24104 STOCHASTIC PROCESSES

UNIT-I

Random Variables, Distribution Functions, Discrete Random Variables-Joint Probability Mass Functions, Continuous Random Variables-Joint Probability Density Functions, Conditional Distributions, Conditional Means and Conditional Variances, N-Variate Random Variables, Special Distributions-Examples, Functions of Random Variables, Expectation and Limit Theorems-Functions of One Random Variables-Functions of Two Random Variables-Functions of n Random Variables-Expectation-Moment Generating Functions-Characteristic Functions-The Laws of Large Number and the Central Limit Theorem-Examples.

UNIT-II

Stochastic Processes-Definitions-Expectations-Vector process-Gaussian process-Harmonic process-Stationary process-Scalar process, Vector process, Correlation length-Ergodic process-Statistical properties of time averages, Temporal density estimation-Poisson process-
Compound Poisson process-Markov process-Examples.

UNIT-III

Stochastic Calculus-Modes of convergence-Stochastic differentiation-Statistical properties of derivative process, Spectral analysis of derivative processes. Stochastic integration-Statistical properties of stochastic integrals, Integration of weakly stationary processes, Riemann–Stieltjes integrals. Itô calculus-Brownian motion, Itô and Stratonovich integrals, Itô and Stratonovich differential equations, Itô’s lemma, Moment equations-Examples.

UNIT-IV

FokkerPlanck–Kolmogorov Equation-Chapman–Kolmogorov equation Derivation of the FPK equation-Derivation using Itô’s lemma-Solutions of FPK equations for linear systems-Short-time solution-Improvement of the short-time solution. Path integral solution-Markov chain representation of path integral. Exact stationary solutions- Examples. Kolmogorov Backward Equation-Derivation of the backward equation-Reliability formulation-First-passage time probability.

UNIT-V

Structural Reliability-Modes of failure-Level crossing-Single level crossing, Method of counting process, Higher order statistics of level crossing, Dual level crossing, Local minima and maxima, Envelope processes-Vector process-First-passage reliability based on level crossing-First-passage time probability – general approach-Example of SDOF linear oscillators, Common safe domains, Structural fatigue-S-N model, Rainflow counting, Linear damage model, Time-domain analysis of fatigue damage-Dirlik’s formula for fatigue prediction, Case studies of fatigue prediction-Examples.

REFERENCE BOOKS:

1. Jian-Qiao Sun, Stochastic Dynamics and Control, Elsevies Publishers.
2. Papoulis, Probability, Random Variables, and Stochastic Processes, McGraw-Hill.
3. Hwei P. Hsu, Probability, Random Variables, and Random Processes, Schaum’s Outline Series, McGraw-Hill.

15D24105 SOFTWARE RELIABILITY

UNIT-I: Introduction and Operational Profile

The Need for Reliable Software, Software Reliability Engineering Concepts, Basic definitions, Software practitioners biggest problem, software reliability engineering approach, software reliability engineering process, defining the product, Reliability concepts, software reliability and hardware reliability, developing operational profiles, applying operational profiles, learning operations and run concepts.

UNIT-II: Software Reliability Concepts

Defining failure for the product, common measure for all associated systems, setting system failure intensity objectives, determining develop software failure intensity objectives, software reliability strategies, failures, faults and errors, availability, system and component reliabilities and failure intensities, predicting basic failure intensity.

UNIT-III: Software Reliability Modeling Survey

Introduction, Historical Perspective and Implementation, Exponential Failure Time Class of Models, Weibull and Gamma Failure Time Class of Models, Infinite Failure Category Models, Bayesian Models, Model Relationship, Software Reliability Prediction in Early Phases of the Life Cycle, software reliability growth modeling.

UNIT-IV: Software Metrics for Reliability Assessment

Introduction, Static Program Complexity, Dynamic Program Complexity, Software Complexity and Software Quality, Software Reliability Modeling.

UNIT-V: Software Testing and Reliability

Introduction, Overview of Software Testing, Operational profiles, Time/Structure Based Software Reliability Estimation, Benefits and approaches of SRE, SRE during requirements phase, SRE during implementation phase, SRE during Maintenance phase.

Text Books

1. Handbook of Software Reliability Engineering Edited by Michael R. Lyu, published by IEEE Computer Society Press and McGraw-Hill Book Company.
2. Software Reliability Engineering John D. Musa, second edition Tata McGraw-Hill.

Reference Books

1. Practical Reliability Engineering, Patric D. T. O connor 4th Edition, John Wesley & Sons, 2003.
2. Fault tolerance principles and Practice, Anderson and PA Lee, PHI, 1981.
3. Fault tolerant computing-Theory and Techniques, Pradhan D K (Ed.): Vol 1 and Vol 2, Prentice hall, 1986.
4. Reliability Engineering E. Balagurusamy, Tata McGrawHill, 1994.

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15D24106 RELIABILITY IN ENGINEERING DESIGN

UNIT-I: **Failure Mode and Effect Analysis (FMEA)**
Basic Principles and General Fundamentals of FMEA Methodology- FMEA according to VDA 86- Example of a Design FMEA according to VDA 86- FMEA according to VDA 4.2- Example of a System FMEA Product according to VDA 4.2- Example of a System FMEA Process according to VDA 4.2.

UNIT-II: Fault Tree Analysis (FTA)
General Procedure of the FTA- Qualitative Fault Tree Analysis- Quantitative Fault Tree Analysis- Reliability Graph- Examples.

UNIT-III: Design of Experiments
Analysis of Variance Technique-Strategy of Experimental Design-t test-one and two sample test-F test-one factor at a time-power of analysis of variance tests-Orthogonal design. Completely Randomized design-Randomized Block Design-Latin Square Design-Graeco Latin Squares-Two Factor analysis of variance-Factorial Experiments. Three Factor Experiments-Factorial Experiments in a Regression setting-Incomplete Blocks Design.

UNIT-IV: Product Liability and Planning
History-Product Safety Law-Product Liability Law-Defenses-proof and the Expert Witness-Financial Loss- The future of product Liability- Prevention- Degree of Novelty of a Product, Product Life Cycle, Company Goals and Their Effect. Solution Finding Methods- Conventional Methods, Intuitive Methods, Discursive Methods, Methods for Combining Solutions- Examples.

UNIT-V: Product Development Process
General Problem Solving Process- Flow of Work During the Process of Designing- Activity Planning, Timing and Scheduling, Planning Project and Product Costs, Effective Organization Structures- Interdisciplinary Cooperation, Leadership and Team Behaviour.

REFERENCE BOOKS:

1. G. Haribaskaran, Probability, Queuing Theory & Reliability Engineering, Laxmi publications, Second Edition.
2. D. H. Besterfield, Glen H. Besterfield and M. Besterfield-Sacre, Total Quality Management, Pearson Publications, Third Edition.
3. E. Walpole, H. Myers and L. Myers, Probability and Statistics for engineering and Scientists, Pearson Publications, Eighth Edition.
4. Brend Bretsche, Reliability in Automotive and Mechanical Engineering, Springer Publications.
5. G. Pahl, W. Bietz, J. Feldhusen and K. H. Grote, Engineering Design a Systematic approach, Springer Publications, Third Edition.

15D24107 INFORMATION SECURITY

UNIT-I

Security Attacks (Interruption, Interception, Modification and Fabrication), Security Services (Confidentiality, Authentication, Integrity, Non-repudiation, access Control and Availability) and Mechanisms, A model for Internetwork security, Internet Standards and RFCs, Buffer overflow & format string vulnerabilities, TCP session hijacking, ARP attacks, route table modification, UDP hijacking, and man-in-the-middle attacks.

UNIT-II

Conventional Encryption Principles, Conventional encryption algorithms, cipher block modes of operation, location of encryption devices, Key distribution Approaches of Message Authentication, Secure Hash Functions and HMAC.

UNIT-III

Public key cryptography principles, public key cryptography algorithms, digital signatures, digital Certificates, Certificate Authority and key management Kerberos, X.509 Directory Authentication Service. Email privacy: Pretty Good Privacy (PGP) and S/MIME.

UNIT-IV

IP Security Overview, IP Security Architecture, Authentication Header, Encapsulating Security Payload, Combining Security Associations and Key Management, Web Security Requirements, Secure Socket Layer (SSL) and Transport Layer Security (TLS), Secure Electronic Transaction (SET)

UNIT-V

Basic concepts of SNMP, SNMPv1 Community facility and SNMPv3, Intruders, Viruses and related threats, Firewall Design principles, Trusted Systems, Intrusion Detection Systems

TEXT BOOKS:

1. Network Security Essentials (Applications and Standards); William Stallings, PEA.
2. Hack Proofing your network; Ryan Russell, Dan Kaminsky, Rain Forest Puppy, Joe Grand, David Ahmad, Hal Flynn Ido Dubrawsky, Steve W.Manzuik and Ryan Permeh, wiley Dreamtech,

REFERENCES:

1. Fundamentals of Network Security; Eric Maiwald, Dreamtech.
2. Network Security - Private Communication in a Public World; Charlie Kaufman,
3. Radia Perlman and Mike Speciner, PEA/PHI.
4. Cryptography and network Security, Stallings, 3e, PHI/PEA.
5. Principles of Information Security, Whitman, Thomson.
6. Network Security: The complete reference, Robert Bragg, Mark Rhodes, TMH
7. Introduction to Cryptography, Buchmann, Springer.

15D22102 ADVANCED DIGITAL SIGNAL PROCESSING

UNIT-I:

Short introduction, Analog to digital and Digital to Analog conversion, sampled and Hold circuit, Continuous time Fourier Transforms. Discrete-time signals and systems, Discrete-time Fourier transform- its properties and applications, Fast Fourier Transform (in time-domain and Frequency domain) , IDFT and its properties.

UNIT-II: z- Transforms

Definition and properties, Rational z-transforms, Region of convergence of a rational z- Transform, The inverse z- Transform, Z-Transform properties, Computation of the convolution sum of finite-length sequences, The transfer function.

Digital Filter Structures: Block Diagram representation, Equivalent structures, Basic FIR Digital Filter structures, Basic IIR Digital Filter structures, Realization of Basic structures using MATLAB, All pass filters, Computational complexity of Digital filter structures.

UNIT III: **IIR Digital Filter Design:**

Preliminary considerations, Bilinear transformation method of IIR Filter design, Design of low pass IIR Digital filters, Design of High pass, Band pass and band stop IIR digital filters, Spectral Transformations of IIR filter, IIR digital filter design using MATLAB, Computer aided design of IIR digital filters.

UNIT IV:FIR Digital Filter Design:

Preliminary considerations, FIR filter design based on windowed Fourier series, Computer aided design of Equiripple Linear phase FIR filters, Design of Minimum phase FIR filters, FIR digital filter design using MATLAB, Design of computationally efficient FIR digital filters.

UNIT V: Analysis of Finite word length effects:

The quantization process and errors, quantization of Fixed point numbers, Quantization of floating point numbers, Analysis of coefficient quantization effects, Analysis of arithmetic round off errors, Low sensitivity digital filters, Reduction of product round off errors using error feedback, Round off errors in FFT algorithms. The basic sample rate alteration devices, Multi rate structures for sampling rate conversion, Multistage design of decimator and interpolator, The Polyphase decomposition, Arbitrary-rate sampling rate converter, Nyquist Filters and some applications of digital signal processing.

Text Books:

1. S.K. Mitra**, Digital Signal Processing-**, Tata McGraw-Hill, Third Edition, 2006.
2. B.P. Lathi, **Principle of Signal Processing and Linear Systems-**, Oxford International Student Version, 2009
3. M. Mondal and A Asif, **Continuous and Discrete Time Signals and Systems**, Cambridge, 2007

References:

1. Li Tan, **Digital Signal Processing- Fundamentals and Applications-**, Indian reprint, Elsevier, 2008.

2. Alan V. Oppenheim, Ronald W. Schafer, and John R.Buck, **Discrete- Time Signal Processing-**, Pearson Edu, 2008.

15D24108 RELIABILITY TOOLS LAB

CYCLE-I: DEMO EXPERIMENTS

1. **MATLAB Commands and Examples**
2. **Built-in functions**

RELIABILITY SOFTWARE MODULES

3. **SPARE Software package**
4. **Failure Mode Software Package**
5. **FMEA-RPN Software package**
6. **SPC Software package**

CYCLE-II: TESTING PROGRAMS

1. **Characteristics of Binomial and Poisson distributions**
2. **Characteristics of Exponential and Weibull distributions**
3. **Characteristics of Normal and Log-Normal distributions**
4. **Determination of MTTF for series and parallel systems**
5. **Evaluation of Limiting State Probabilities (LSPs)**
6. **Evaluation of basic probability indices for series and parallel systems**
7. **Parametric Boot-Strap estimation and finding best parameters**
8. **Chi-Square Goodness of Fit**
9. **Determination of Covariance, Correlation and Cross-Correlation coefficients**
10. **Neural Network design to Block box models**
11. **Testing of sampling methods**
12. **Characteristics of Histogram, Scatter diagram, Process Flow diagram and Pareto diagram**

15D24201 SIX SIGMA CONCEPTS

UNIT-I:

Introduction to Six-Sigma-Probabilistic models-Six Sigma measures-Yield-DPMO-Quality level-Reliability function using Six-Sigma-MTTF using Six Sigma-Maintenance free operating period- Availability using Six-Sigma-Point availability-Achieved availability-Operational Availability-Examples.

UNIT-II:

The Elements of Six Sigma and their Determination-The Quality Measurement Techniques: SQC, Six Sigma, Cp and Cpk- The Statistical quality control (SQC) methods-The relationship of control charts and six sigma-The process capability index (Cp)-Six sigma approach-Six sigma and the 1.5 σ shift-The Cpk Approach Versus Six Sigma-Cpk and process average shift-Negative Cpk-Choosing six sigma or Cpk-Setting the process capability index-Examples.

UNIT-III:

Calculating Defects Using Normal Distribution-Relationship between *z* and Cpk-Example defect calculations and Cpk-Attribute processes and reject analysis for six sigma-Quick visual check for normality-Checking for normality using chi-square tests-Example of x^2 goodness of fit to normal distribution test-Transformation data into normal distributions-The use of statistical software for normality analysis-Examples.

UNIT-IV:

Basic QC and Six Sigma Tools-The 7 QC Tools-Process Flowchart and Process Mapping-Quality Function Deployment (QFD)- Six Sigma and Design of Experiments (DoE)-DoE Definitions and Expectations-DoE objectives and expectations- DoE Techniques-Steps in conducting a successful DoE-experiment - Types of DoE using orthogonal arrays-Two-level orthogonal arrays-Three-level orthogonal arrays- The Taguchi design-The DoE Analysis Tool Set - Orthogonal array L9 saturated design- Bonding process optimization- Examples.

UNIT-V:

Introduction - Product Life Cycle and the Six Sigma Design-Quality Issues-Changes in product design-Changing traditional design communications and supplier involvement-Design process communications needs-Examples.

REFERENCE BOOKS:

1. U Dinesh Kumar, Crocker, Chitra and Harithe Saranga, Reliability and Six Sigma, Springer Publishers.
2. Sung H. Park, Six Sigma for Quality and Productivity Promotion, Asian Productivity Organization
3. Sammy G. Shina, Six Sigma for Electronics Design and Manufacturing, McGraw-Hill.

15D24202 RISK ASSESSMENT AND MANAGEMENT

UNIT- I:

Basic concepts of Risk-Analysis-Process-planning and Assessment-Risk treatment-Risk analysis methods-Coarse Risk Analysis-Job Safety Analysis-FMEA-Hazard and Operability Studies-SWIFT-Bayesian networks.

UNIT-II:

Human Reliability-Human Errors-Characteristics-Modes of Error detection-Human and Technical reliability-Task Performance-Human Reliability Assessment techniques-Technique for Human error Rate Prediction (THERP)-Human performance data-Human Reliability Enhancement. Human error in maintenance-System Life Cycle-Reasons for maintenance error-Reducing human errors-Prediction techniques-Markov model-Fault Tree Analysis-Examples.

UNIT-III:

Terotechnology-Definitions-System-Process-Programmes-Total Productive maintenance-Strategies-Training Programmes-for project operation managers-maintenance supervisors.

UNIT-IV:

Risk management-Objectives-Definitions-Process-Risk Identification and Approaches-Risk Statement-Risk Prioritization-Borda Algorithm-Value function approach-Ranking-Risk events-Additive value model-Formulations-Incorporating uncertainty-models-Progress monitoring. Spare Parts Management-Inventory Control-Functional Classifications-Advantages-Features-Economic order quantity and its model-Inventory Control approaches-Multi item Inventory control-Classifications-Man power resource and Spares requirement planning-Flow chart-Examples.

UNIT-V:

Verification and Validation-Basic concepts-Management-Planning-Requirements-Systems approaches-Managing Plan-Effectiveness measures-Risk management-Flow Chart-Communication Structures-Internal and Independent information flows. Life Cycle Analysis-Traceability Analysis-Interface Analysis-Phase dependent analysis-Testing-Hierarchy of test documents.

REFERENCE BOOKS:

1. Terje Aven, Risk Analysis Assessing Uncertainties beyond Expected Values and Probabilities, John Wiley and Sons Publication.
2. Sue Cox and Robin Tait, Safety, Reliability and Risk Management: an integrated approach, Second edition, Butterworth-Heinemann Publications.
3. B. S. Dhillon, Engineering Maintenance A Modern Approach, CRC Press.
4. A. K. Gupta, Reliability, Maintenance and Safety Engineering, University Science Press.
5. Analytical Methods for Risk Management A Systems Engineering Perspective, Paul R. Garvey, CRC Press.
6. Marcus S. Fisher, Software Verification and Validation an Engineering and Scientific Approach, Springer Publishers.

15D24203 MAINTENANCE ENGINEERING AND MANAGEMENT

UNIT-I:
Maintenance engineering objectives-Basic principles and approaches-Types of maintenance-Specifications and functions-Systems approach-performance indices-planning and control-Strategy.

UNIT-II:
Maintenance management and control-functions and organization-critical maintenance-effective elements-project control methods-control indices - Maintainability-Concepts-tasks-modeling and allocation-prediction-FMECA-reliability and maintainability trade off-Design for maintainability-design methods. .

UNIT-III:
Preventive maintenance-elements and principle-measures-mathematical models-Advantages and disadvantages - Corrective maintenance-types-measures-mathematical models-effective failure rate equations - Reliability Centered Maintenance-goals and principles-components-predictive testing and Inspection techniques-effective measurement indicators-Advantages.

UNIT-IV:
Quality in Maintenance-Processes-Control Charts-Post maintenance testing-Maintenance Safety-maintenance tasks-improving safety-personnel safety.

UNIT-V:
Maintenance costing-factors-budget type and approaches-labor cost estimation-material cost estimation-cost estimation model-cost related indices-economic analysis-Convex and Concave costs-profit and life cycle cost trade offs.

REFERENCS BOOKS:

1. A. K. Gupta, Reliability, Maintenance and Safety Engineering,
2. B. S. Dhillon, Engineering Maintenance A Modern Approach, CRC Press.
3. Charles E. Ebeling, Reliability and Maintainability Engineering, Tata McGraw Hill, 2000.

15D24204 RELIABLE & FAULT TOLERANT COMPUTING

UNIT-I:

Introduction - Definitions - Organization and Intended Use - Means to Achieve Dependable Software - Fault Avoidance or Prevention - Fault Removal - Fault/Failure Forecasting - Fault Tolerance - Types of Recovery - Backward Recovery - Forward Recovery - Software Fault Tolerance - Acceptance Tests - Single-Version Fault Tolerance – Wrappers - Software Rejuvenation - Data Diversity - Software Implemented Hardware Fault Tolerance (SIHFT) - *N*-Version Programming - Consistent Comparison Problem – Version - Independence - Recovery Block Approach - Basic Principles - Success Probability Calculation - Distributed Recovery Blocks - Preconditions, Post Conditions, and Assertions - Exception-Handling - Requirements from Exception-Handlers - Basics of Exceptions and Exception-Handling - Language Support.

UNIT-II:

Checkpointing - Checkpointing Nontrivial - Checkpoint Level - Optimal Checkpointing – An Analytical Model - Time Between Checkpoints - A First-Order Approximation – Optimal Checkpoint Placement - Time Between Checkpoints - A More Accurate Model – Reducing Overhead - Reducing Latency - Cache-Aided Rollback Error Recovery (CARER) - Checkpointing in Distributed Systems - The Domino Effect and Livelock - A Coordinated Checkpointing Algorithm - Time-Based Synchronization - Diskless Checkpointing - Message Logging - Checkpointing in Shared-Memory Systems - Other Uses of Checkpointing.

UNIT-III:

Fault Detection Methods – Fault Models – Basic Models – Process Models – Theoretical and Experimental Modeling – Static Process Models – Linear Dynamic Process Models – Signal Models - Harmonic Oscillations – Signal Oscillations – Superposition – Amplitude Modulation – Frequency and Phase Modulation – Beating (Libreation) – Characteristics – Stochastic Signals – Fault Detection with Limit Checking – Limit Checking of Absolute Values – Trend Checking –Examples.

UNIT-IV:

Fault Diagnosis with Classification Methods – Simple Pattern Classification Methods – Bayes Classification – Geometric Classifiers – Polynomial Classification – Decision Trees – Fault Tolerant Systems – Fault Tolerant Design – Basic Redundant Structures – Degradation Steps – Fault Tolerant Components and Control – Fault Tolerant Sensors – Fault Tolerant Actuators – Communication – Fault Tolerant Control Systems - Examples.

UNIT-V:

Hardware Fault Tolerance – Voters - Variations on *N*-Modular Redundancy - Duplex Systems - Fault-Tolerance Processor-Level Techniques - Watchdog Processor - Simultaneous Multithreading for Fault Tolerance - Byzantine Failures - Byzantine Agreement with Message Authentication – Examples.

REFERENCE BOOKS:

1. Laura L. Pullum, Software fault Tolerance Techniques and Implementation, Artech House Publishers.
2. Israel Koren and C. Mani Krishna, Fault Tolerant Systems, Morgan Kaufmann Publishers is an imprint of Elsevier.
3. Rolf Isermann, Fault-Diagnosis Systems An Introduction from Fault Detection to Fault Tolerance, Springer Publishers.

15D24205 RELIABILITY OPTIMIZATION

UNIT-1:
Partially redundant systems-Standby redundant systems-redundancy concepts-perfect switching-imperfect switching-standby redundancy calculations-Component versus unit redundancy-Weakest-Link Technique-Mixed Redundancy-Redundancy Optimization-Double Failures and Redundancy.

UNIT-II:
Systems Model-Statement of the various optimization problems- Heuristic Methods applied to optimal systems reliability-A heuristic method : Sharma And Venkateswran's Approach, Aggrawal's Approach, Mishra's Approach, Ushakov's Approach, Nakagawa and Nakashima's Approach.

UNIT-III:
Dynamic programming applied to optimal systems reliability-Basic dynamic programming approach-Dynamic programming approach using Lagrange multipliers-The discrete maximum principle applied to optimal systems reliability-Sequential unconstrained minimization technique(SUMT) applied to optimal systems reliability-Generalized reduced gradient method(GRG) applied to optimal Systems reliability.

UNIT-IV:
Method of Lagrange multipliers-single constraint problem-single linear constraint problem-two linear constraint problem-Generalized Lagrangian function method applied to optimal systems reliability-Generalized Lagrangian problem-computational procedures- KUHN-TUCKER conditions in optimal systems reliability and for the two linear constraint problem-
The geometric programming applied to optimal systems reliability- Examples.

UNIT-V:
Integer programming applied to optimal systems reliability-Introduction-The partial Enumeration method-The Gomory Cutting plane method-The branch and bound method-The Geoffrion Implicit Enumeration method-Parametric method-Linear programming-Separable Programming Methods-Examples.

REFERENCE BOOKS:
1. F. A. Tillman, C. V. Hwang & W. Kuo, Optimization of Systems Reliability, Marcel Dekker Inc.
2. S. S Rao, Engineering Optimization Theory and Practice, New Age International Publications, Third edition.
3. E. Balagurusamy, Reliability Engineering, Tata McGraw-Hill Publishing Company Limited.
4. J. K. Sharma, Operations Research Theory and Appliactions, Macmillan Publications, 4th Edition.

15D24206 MONTE CARLO SIMULATION

UNIT-I:

Basic concepts-Features-Efficiency-Convergence Characteristics-Random number generation-Linear Congruential generators-Random variate generation-Inverse Transform method-Tabulating technique- Generating random numbers from discrete distributions- Binomial Distribution- Poisson Distribution-Geometric Distribution-Negative Binomial Distribution-Hypergeometric Distribution-Monte Carlo Integration-The Hit or Miss, The Sample-Mean Monte Carlo Methods-Efficiency of Monte Carlo Method-Comparison.

UNIT-II:

Generating random functions from continuous distributions - Exponential Distribution - Gamma Distribution - Beta Distribution - Normal Distribution - Lognormal Distribution - Cauchy Distribution - Weibul Distribution - Chi-Square Distribution-Procedures and Algorithms.

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UNIT-III:

Variance Reduction Techniques-Importance Sampling-Correlated Sampling-Control Variates-Stratified Sampling-Antithetic Variates-Partition of the Region-Reducing the Dimensionality-Conditional Monte Carlo-Random Quadrature Method-Biased Estimators-Weighted Monte Carlo Integration.

UNIT-IV:

Discrete event simulation-Poisson process-Time-dependent Poisson process-Poisson processes in the plane-Markov chains-Discrete-time Markov chains-Continuous-time Markov chains-Regenerative analysis- Markov chains-Bayesian statistics- The Metropolis–Hastings (MH) algorithm- Regenerative Simulation-Point Estimators and Confidence Intervals-Examples of Regenerative Processes-Variance Reduction Techniques- Examples.

UNIT-V:

Monte Carlo Optimization-Random search Algorithms-Efficiency of Random Search Algorithms-Local and Integral Properties of Optimum Trial Random search Algorithm- Global Optimization-A Closed form Solution -Examples.

REFERENCE BOOKS:

1. Roy Billinton and Wenyuan Li, Reliability Assessment of Electric Power Systems Using Monte Carlo Methods, Plenum Press, New York.
2. Reuven Y. Rubinstein, Simulation and The Monte Carlo Method, John Wiley & Sons publishers.
3. J. S. Dagpunar, Simulation and Monte Carlo, John Wiley & Sons Publishers.

15D21201 POWER SYSTEM RELIABILITY

UNIT-I : Generating System Reliability Analysis – I
Generation system model – Capacity outage probability tables – Recursive relation for capacitive model building – Sequential addition method – Unit removal – Evaluation of loss of load and energy indices – Examples.

UNIT-II : Generating System Reliability Analysis – II
Frequency and Duration methods – Evaluation of equivalent transitional rates of identical and non-identical units – Evaluation of cumulative probability and cumulative frequency of non-identical generating units – 2-level daily load representation - Merging generation and load models – Examples.

UNIT-III : Bulk Power System Reliability Evaluation
Basic configuration – Conditional probability approach – System and load point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model – Common mode failures.

UNIT-IV : Distribution System Reliability Analysis – I (Radial Configuration)
Basic Techniques – Radial networks – Evaluation of Basic reliability indices, performance indices - Load point and system reliability indices – Customer oriented, loss and energy oriented indices – Examples.

UNIT-V : Distribution System Reliability Analysis - II (Parallel Configuration)
Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects – Common mode failures – Evaluation of various indices – Examples.

Text Books:

1. Roy Billinton and Ronald N. Allan, Reliability Evaluation of Power Systems, Plenum Press, New York and London, 2^{nd} Edition, 1996.
2. J. Endrenyi , Reliability Modeling in Electric Power Systems, John Wiley & Sons, 1^{st} Edition, 1978.

15D22203 INTELLIGENT ALGORITHMS

UNIT I: Introduction and motivation. Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule - based systems, the AI approach. Knowledge representation. Expert systems. Data Pre - Processing: Scaling, Fourier transformation, principal - component analysis and wavelet transformations.

UNIT II

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch - Pitts neuron model, simple perceptron, Adaline and Madaline, Feed - forward Multilayer Perceptron. Learning and Training the neural network. Networks: Hopfield network, Self - organizing network and Recurrent network. Neural Network based controller, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab / Neural Network toolbox.

UNIT III

Genetic Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other than GA search techniques like tabu search and ant - colony search techniques for solving optimization problems.

UNIT IV

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to Fuzzy logic modeling and control of a system. Fuzzification, inference and defuzzification. Fuzzy knowledge and rule bases.

UNIT V

Fuzzy modeling and control schemes for nonlinear systems. Self - organizing fuzzy logic control. Implementation of fuzzy logic controller using Matlab fuzzy - logic toolbox. Stability analysis of fuzzy control systems. Intelligent Control for SISO/MIMO Nonlinear Systems. Model Based Multivariable Fuzzy Controller.

Text Books

1. Simon Haykins, Neural Networks: A comprehensive Foundation, Pearson Edition, 2003.
2. T.J.Ross, Fuzzy logic with Fuzzy Applications, Mc Graw Hill Inc, 1997.
3. David E Goldberg, Genetic Algorithms.

References

1. M.T.Hagan, H. B. Demuth and M. Beale, Neural Network Design, Indian reprint, 2008.
2. Fredric M.Ham and Ivica Kostanic, Principles of Neurocomputing for science and Engineering, McGraw Hill, 2001.
3. N.K. Bose and P.Liang, Neural Network Fundamentals with Graphs, Algorithms and Applications, Mc - Graw Hill, Inc. 1996.
4. Yung C. Shin and Chengying Xu, Intelligent System - Modeling, Optimization and Control, CRC Press, 2009.
5. N.K.Sinha and Madan M Gupta, Soft computing & Intelligent Systems - Theory & Applications, Indian Edition, Elsevier, 2007.
6. John Yen and Reza Langari, Fuzzy logic Intelligence, Control, and Information, Pearson Education, Indian Edition, 2003.
7. Witold Pedrycz, Fuzzy Control and Fuzzy Systms, Overseas Press, Indian Edition, 2008.

15D54201 RESEARCH METHODOLOGY

(Audit Course)

UNIT I

Meaning of Research – Objectives of Research – Types of Research – Research Approaches – Guidelines for Selecting and Defining a Research Problem – research Design – Concepts related to Research Design – Basic Principles of Experimental Design.

UNIT II

Sampling Design – steps in Sampling Design –Characteristics of a Good Sample Design – Random Sampling Design.
Measurement and Scaling Techniques-Errors in Measurement – Tests of Sound Measurement – Scaling and Scale Construction Techniques – Time Series Analysis – Interpolation and Extrapolation.
Data Collection Methods – Primary Data – Secondary data – Questionnaire Survey and Interviews.

UNIT III

Correlation and Regression Analysis – Method of Least Squares – Regression vs Correlation – Correlation vs Determination – Types of Correlations and Their Applications

UNIT IV

Statistical Inference: Tests of Hypothesis – Parametric vs Non-parametric Tests – Hypothesis Testing Procedure – Sampling Theory – Sampling Distribution – Chi-square Test – Analysis of variance and Co-variance – Multi-variate Analysis.

UNIT V

Report Writing and Professional Ethics: Interpretation of Data – Report Writing – Layout of a Research Paper – Techniques of Interpretation- Making Scientific Presentations in Conferences and Seminars – Professional Ethics in Research.

Text books:

1. **Research Methodology:Methods and Techniques – C.R.Kothari, 2nd Edition,New Age International Publishers.**
2. **Research Methodology: A Step by Step Guide for Beginners- Ranjit Kumar, Sage Publications (Available as pdf on internet)**
3. **Research Methodology and Statistical Tools – P.Narayana Reddy and G.V.R.K.Acharyulu, 1st Edition,Excel Books,New Delhi.**

REFERENCES:

1. **Scientists must Write - Robert Barrass (Available as pdf on internet)**
2. **Crafting Your Research Future –Charles X. Ling and Quiang Yang (Available as pdf on internet)**

15D24207 RELIABILITY TESTING LAB

CYCLE-I: DEMO EXPERIMENTS

1. **MATLAB Commands and Examples**
2. **Built-in functions**

RELIABILITY SOFTWARE MODULES

3. **Reliability Centered Maintenance**
4. **RELTEST – Reliability Compliance and Determination Testing**

CYCLE-II: TESTING PROGRAMS

1. **Component and Unit Redundancy with Exponential Distribution**
2. **Chi-Square Goodness of Fit**
3. **Optimal Redundancy Calculations**
4. **Calculation of Correlation Co-efficient & Co-efficient of Co-variance**
5. **Control Charts for Variable to obtain the control limits and PCR**
6. **Method of Least Squares to fit the Regression Lines**
7. **ANOVA (Analysis of Variation)**
8. **MLE (Maximum Likely Hood Estimation) of Normal Distribution**
9. **Evaluation of Cumulative probability and Cumulative Frequency of Merged States**
10. **Analysis of Bi-Variant Method**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR
JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) :: ANANTHAPURAMU
Ananthapuramu – 515 002, Andhra Pradesh, India

Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

RELIABILITY ENGINEERING

I SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D91101	System Reliability Concepts	PC	3	0	0	3
2	21D91102	Life Testing & Reliability Estimation	PC	3	0	0	3
3	**Professional Elective – I**						
	21D91103	Software Reliability	PE	3	0	0	3
	21D91104	Reliable & Fault Tolerant Computing					
	21D91105	Information Security					
4	**Professional Elective – II**						
	21D91106	Six Sigma Concepts	PE	3	0	0	3
	21D91107	Reliability in Engineering Design					
	21D91108	Monte Carlo Simulation					
5	21D11109	Research Methodology and IPR	MC	2	0	0	2
6	21D11110	English for Research Paper Writing	AC	2	0	0	0
	21D11111	Value Education					
	21D11112	Pedagogy Studies					
7	21D91109	Probabilistic Distribution Simulation Lab	PC	0	0	4	2
8	21D91110	Reliability Life Testing Simulation Lab	PC	0	0	4	2
Total				**16**	**00**	**08**	**18**

Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

RELIABILITY ENGINEERING

II SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D91201	R - Programming	PC	3	0	0	3
2	21D91202	Stochastic Process	PC	3	0	0	3
3	**Professional Elective – III**						
	21D91203	Risk Assessment and Management	PE	3	0	0	3
	21D91204	Maintenance Engineering & Management					
	21D91205	Reliability Optimization					
4	**Professional Elective – IV**						
	21D91206	Statistical Quality Control	PE	3	0	0	3
	21D91207	Power System Reliability					
	21D91208	Intelligent Algorithms					
5	21D11209	Technical Seminar	PR	0	0	4	2
6	21D11210	Disaster Management	AC	2	0	0	0
	21D11211	Constitution of India					
	21D11212	Stress Management by Yoga					
7	21D91209	Network Reliability Simulation Lab	PC	0	0	4	2
8	21D91210	R – Programming Lab	PC	0	0	4	2
Total				**16**	**00**	**08**	**18**

RELIABILITY ENGINEERING

III SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	**Professional Elective – V**						
	21D91301	Python Programming	PE	3	0	0	3
	21D91302	Statistical Techniques in Big Data Analysis					
	21D91303	Statistical Techniques in Machine Learning					
2	**Open Elective**						
	21D20301	Waste to Energy	OE	3	0	0	3
3	21D91304	Dissertation Phase – I	PR	0	0	20	10
4	21D00301	Co-Curricular Activities	PR				2
Total				**06**	**00**	**20**	**18**

IV SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D91401	Dissertation Phase – II	PR	0	0	32	16
Total				**00**	**00**	**32**	**16**

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91101	SYSTEM RELIABILITY CONCEPTS (21D91101)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- Understand the basic concepts of probability, network reduction, reliability functions, Markov process and reliability indices.
- Analyse the concept of distributions, path based and cutset based approach, failure density functions, repairable models and recursive relations.
- Apply the network reliability methods to find the system reliability and basic reliability indices.
- Develop the techniques to evaluate the reliability of the system.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concepts of failure density functions, types of redundancies, reliability functions, repairable models and basic probability indices.
CO 2: Analyse the importance of reliability in various fields.
CO 3: Apply the reliability methods to evaluate the system reliability and component reliability.
CO 4: Develop the various methods for reliability evaluation of the power system.

UNIT – I	**Basic Probability Theory**	Lecture Hrs: 8

Basic concepts – Rules for combining Probabilities of events – Failure Density and Distribution functions – Bernoulli's trials – Binomial distribution – Expected value and standard deviation for binomial distribution – Examples.

UNIT - II	**Network Modelling and Reliability Evaluation**	Lecture Hrs:12

Basic concepts – Evaluation of network Reliability / Unreliability – Series systems, Parallel systems, Series - Parallel systems, partially redundant systems – Types of redundancies - Evaluation of network Reliability / Unreliability using conditional probability method – Paths based and Cutset based approach – complete event tree and reduced event tree methods - Examples.

UNIT - III	**Time Dependent Probability**	Lecture Hrs:10

Basic concepts – Reliability functions f(t), F(t), R(t), h(t) – Relationship between these functions – Bath tub curve – Exponential failure density and distribution functions - Expected value and standard deviation of Exponential distribution – Measures of reliability – MTTF, MTTR, MTBF, MTTF – Evaluation of network reliability / Unreliability of simple Series, Parallel, Series-Parallel systems - Partially redundant systems - Evaluation of reliability measure – MTTF for series and parallel systems – Examples.

UNIT - IV	**Discrete Markov Chains & Continuous Markov Processes**	Lecture Hrs:14

Basic concepts – Stochastic transitional Probability matrix – time dependent probability evaluation – Limiting State Probability evaluation – Absorbing states – Markov Processes-Modelling concepts – State space diagrams – time dependent reliability evaluation of single component repairable model – Evaluation of Limiting State Probabilities of one, two component repairable models – Frequency and duration concepts – Frequency balance approach – Examples, First Order and Second Order Markov Modelling, Hidden Markov Model.

UNIT - V	**Multi Component & Approximate System Reliability Evaluation**	Lecture Hrs:10

Recursive relation for evaluation of equivalent transitional rates, cumulative probability and cumulative frequency and 'n' component repairable model - Series systems, Parallel systems, Basic reliability indices – Cutset approach – Examples.

Textbooks:

1. V. Sankar "System Reliability Concepts", Himalaya Publishing House, 1st Edition, 2015.
2. Roy Billinton and Ronald N. Allan, "Reliability Evaluation of Engineering Systems",Plenum Publishing Corporation, 2nd Edition,1992.

Reference Books:

1. E. Balagurusamy, "Reliability Engineering", McGraw Hill Education, 1st Edition, 2017.
2. Charles E. Ebeling, "An Introduction to Reliability and Maintainability Engineering", Waveland Press, Inc., 3rd Edition, 2019.
3. George J. Anders, "Probability Concepts in Electric Power system", Wiley-Interscience, 1st Edition, 1990.

Online Learning Resources:

1. https://www.google.co.in/books/edition/Reliability_Engineering/hEBD615hkzwC?hl=en&gbpv=1&dq=SYSTEM+RELIABILITY+CONCEPTS&printsec=frontcover

Course Code	21D91102	LIFE TESTING & RELIABILITY ESTIMATION (21D91102)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

Course Outcomes (CO): Student will be able to

UNIT – I		Lecture Hrs:

Probability Distribution Functions - Discrete distributions - Uniform distribution, Marginal Distribution, Negative binomial distribution and Geometric distribution. Continuous distribution - Exponential distribution, double exponential, Rayleigh distribution, Weibull distribution, Gamma distribution, Beta distribution, Pareto distribution, Normal distribution and lognormal distribution - Sampling distribution - Correlation – The concept of Correlation, measuring correlation - Auto and cross correlation functions – Properties.

UNIT - II		Lecture Hrs:

Interval Estimation - Unbiased Estimators, Interval Estimates (Confidence Intervals), Prediction Intervals, Central Limit Theorem, Parametric Bootstrap Estimation - Parameter estimation - Unbiased estimators - Point estimators - Properties of point estimators - Maximum likelyhood estimation - Bayes estimation - Mean Square estimation - Linear mean square estimation - Examples.

UNIT - III	Reliability Life Testing Methods	Lecture Hrs:

Reliability Life Testing - Test time calculations, Burn-in testing, Acceptance testing, accelerated life testing and Experimental Design - Reliability Growth Testing - Growth process, Idealized growth curve and other growth modals. Goodness of Fit tests - Chi-square goodness of fit test, Bartlett’s test for the exponential distribution, Mann’s test for the weibull distribution, kolmogorovsmirnov test for normal and lognormal distributions and tests for the power law process model.

UNIT - IV		Lecture Hrs:

Baye’s testing and Testing Hypotheses - Terminology in Statistical Tests of Hypotheses, Hypothesis Tests: Means, Hypothesis Tests: Proportions, Hypothesis Tests for Difference between Two Means: Small Samples - Known, Hypothesis Test with Paired Samples, Hypothesis Tests: Variances, Hypothesis Tests for Independence, Homogenity, and Goodness of Fit.

UNIT - V		Lecture Hrs:

Non-Parametric Methods -Introduction, The Sign Test, Nonparametric Bootstrap Estimation, The Sign Test for Paired Data, The Wilcoxon Signed - Rank Test, Wilcoxon – Mann -Whitney (WMW) Rank Test for Two Samples, Spearman Rank Order Correlation Coefficient, Kendall’s Rank Correlation Coefficient (t), Nonparametric Tests for Regression, Nonparametric Tests for ANOVA, Runs Test and Randomization Tests.

Textbooks:

1. E Balagurusamy, “Reliability Engineering”, Tata McGraw-Hill, 1st Edition, 2010.
2. S. K. Sinha, “Reliability and Life Testing”, Wiley Eastern Ltd., 1st Edition, 1986.

Reference Books:
1. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw-Hill, 3rd Edition, 2019. 2. Ronald Deep, "Probability and Statistics", Elsevier Publishers, 1st Edition, 1969.
Online Learning Resources:
1. https://nptel.ac.in/courses/105/108/105108128/

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91103	SOFTWARE RELIABILITY (21D91103) (PE – I)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives:
- To discuss the problems of reliability specification and measurement.
- To introduce reliability metrics and to discuss their use in reliability specification.
- To show how reliability predications may be made from statistical test results.

Course Outcomes (CO): Student will be able to
CO 1: Understand the software reliability engineering concepts, failures, faults and errors.
CO 2: Apply the concept of operational profiles, neural networks for software reliability.
CO 3: Analyze the concept of software reliability modeling.
CO 4: Develop the concept of operational profiles.

UNIT - I	Fundamental to Software Reliability	Lecture Hrs:

The Need for Reliable Software, Software Reliability Engineering Concepts, Basic definitions, Software practitioners biggest problem, software reliability engineering approach, software reliability engineering process, defining the product.
The Operational Profile: Reliability concepts, software reliability and hardware reliability, developing operational profiles, applying operational profiles, learning operations and run concepts.

UNIT - II	Software Reliability Concepts	Lecture Hrs:

Defining failure for the product, common measure for all associated systems, setting system failure intensity objectives, determining develop software failure intensity objectives, software reliability strategies, failures, faults and errors, availability, system and component reliabilities and failure intensities, predicting basic failure intensity.

UNIT - III	Software Reliability Modeling Survey	Lecture Hrs:

Introduction, Historical Perspective and Implementation, Exponential Failure Time Class of Models, Weibull and Gamma Failure Time Class of Models, Infinite Failure Category Models, Bayesian Models, Model Relationship, Software Reliability Prediction in Early Phases of the Life Cycle.

UNIT - IV	Software Metrics for Reliability Assessment	Lecture Hrs:

Introduction, Static Program Complexity, Dynamic Program Complexity, Software Complexity and Software Quality, Software Reliability Modeling.
Software Testing and Reliability: Introduction, Overview of Software Testing, Operational profiles, Time/Structure Based Software Reliability Estimation.

UNIT - V	Best Practice of SRE & Neural Networks for Software Reliability	Lecture Hrs:

Best Practice of SRE: Benefits and approaches of SRE, SRE during requirements phase, SRE during implementation phase, SRE during Maintenance phase.
Neural Networks for Software Reliability: Introduction, Neural Networks, Neural Networks for software reliability, software reliability growth modeling.

Textbooks:

1. Michael R. Lyu, "Handbook of Software Reliability Engineering", IEEE Computer Society Press and McGraw-Hill, 1st Edition, 1996.
2. John D. Musa, "Software Reliability Engineering: More Reliable Software- Faster and Cheaper", Tata McGraw-Hill, 2nd Edition, 2005.

Reference Books:

1. Patric D. T. O connor "Practical Reliability Engineering", John Wesley & Sons, 4th Edition, 2003.
2. Anderson and PA Lee, "Fault Tolerance Principles and Practice", PHI, 1981.
3. Pradhan D K, "Fault tolerant computing-Theory and Techniques", Prentice hall, Vol. 1 and Vol. 2, Prentice hall, 1986.

Online Learning Resources:

1. citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.24.5727...pdf
2. e-archivo.uc3m.es/bitstream/10016/161/1/ws012014.pdf

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91104	RELIABLE & FAULT TOLERANT COMPUTING (21D91104) (PE – I)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- Understand the concept of fault forecasting, exception handling, check pointing levels, fault models, fault tolerant concepts, hardware fault tolerance techniques.
- Analyze the procedure for identifying fault, basic of exceptions, optimal check point, processes models and fault diagnosis.
- Apply the methods to find out success probability calculation, error recovery, message logging, trend checking and fault tolerance.
- Develop the techniques for fault detection and fault diagnosis for complex systems.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concept of fault tolerance, recovery system, optimal check pointing, fault detection, fault classification methods, N-modular redundancy.
CO 2: Analyze the tests on fault tolerance, effects on check pointing, stochastic signals, fault tolerant sensors and actuators.
CO 3: Apply the methods to evaluate fault tolerance check pointing levels fault detection and fault diagnosis.
CO 4: Design the hardware models for finding fault tolerance for practical systems.

UNIT - I	Software Fault Tolerance	Lecture Hrs: 12

Introduction - Definitions - Organization and Intended Use - Means to Achieve Dependable Software - Fault Avoidance or Prevention - Fault Removal - Fault/Failure Forecasting - Fault Tolerance - Types of Recovery - Backward Recovery - Forward Recovery - Software Fault Tolerance - Acceptance Tests - Single-Version Fault Tolerance – Wrappers - Software Rejuvenation - Data Diversity - Software Implemented Hardware Fault Tolerance (SIHFT) - *N*-Version Programming - Consistent Comparison Problem – Version - Independence - Recovery Block Approach - Basic Principles - Success Probability Calculation - Distributed Recovery Blocks - Preconditions, Post Conditions, and Assertions - Exception-Handling - Requirements from Exception-Handlers - Basics of Exceptions and Exception-Handling - Language Support.

UNIT - II	Check Pointing	Lecture Hrs: 10

Check-pointing Nontrivial - Checkpoint Level - Optimal Checkpointing – An Analytical Model - Time Between Checkpoints - A First-Order Approximation – Optimal Checkpoint Placement - Time Between Checkpoints - A More Accurate Model – Reducing Overhead - Reducing Latency - Cache-Aided Rollback Error Recovery (CARER) – Check-pointing in Distributed Systems - The Domino Effect and Livelock - A Coordinated Check-pointing Algorithm - Time-Based Synchronization - Diskless Checkpointing - Message Logging - Checkpointing in Shared-Memory Systems - Other Uses of Checkpointing.

UNIT - III	Fault Detection Methods	Lecture Hrs: 12

Basic Models – Process Models – Theoretical and Experimental Modelling – Static Process Models – Linear Dynamic Process Models – Signal Models - Harmonic Oscillations – Signal Oscillations – Superposition – Amplitude Modulation – Frequency and Phase Modulation – Beating (Liberation) – Characteristics – Stochastic Signals – Fault Detection with Limit Checking – Limit Checking of Absolute Values – Trend Checking –Examples.

UNIT - IV	**Fault Diagnosis**	Lecture Hrs: 10
Simple Pattern Classification Methods – Bayes Classification – Geometric Classifiers – Polynomial Classification – Decision Trees – Fault Tolerant Systems – Fault Tolerant Design – Basic Redundant Structures – Degradation Steps – Fault Tolerant Components and Control – Fault Tolerant Sensors – Fault Tolerant Actuators – Communication – Fault Tolerant Control Systems - Examples.		
UNIT - V	**Hardware Fault Tolerance**	Lecture Hrs: 8
Voters - Variations on *N*-Modular Redundancy - Duplex Systems – Fault Tolerance Processor-Level Techniques - Watchdog Processor - Simultaneous Multithreading for Fault Tolerance - Byzantine Failures - Byzantine Agreement with Message Authentication – Examples.		

Textbooks:

1. Laura L. Pullum, "Software Fault Tolerance Techniques and Implementation", Artech House Publishers, 1st Edition, 2001.
2. Israel Koren and C. Mani Krishna, "Fault-Tolerant Systems", Morgan Kaufmann Publishers is an imprint of Elsevier, 1st Edition, 2007.

Reference Books:

1. Rolf Isermann, "Fault-Diagnosis Systems - An Introduction from Fault Detection to Fault Tolerance", Springer Publishers, 1st Edition, 2006.

Online Learning Resources:

1. https://www.google.co.in/books/edition/Design_And_Analysis_Of_Reliable_And_Faul/3GS7CgAAQBAJ?hl=en&gbpv=1&dq=RELIABLE+%26+FAULT+TOLERANT+COMPUTING&printsec=frontcover

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	**21D91105**	**INFORMATION SECURITY (21D91105) (PE – I)**	**L**	**T**	**P**	**C**
Semester	**I**		**3**	**0**	**0**	**3**

Course Objectives:

- To learn the fundamental concepts of cryptography.
- To defend the security attacks on information systems with secure algorithms.

Course Outcomes (CO): Student will be able to

CO 1: Develop an understanding of information assurance as practiced in computer operating systems, distributed systems, networks and representative applications.
CO 2: Gain familiarity with prevalent network and distributed system attacks.
CO 3: Provide defence against System attacks, and forensics to investigate the aftermath.
CO 4: Develop a basic understanding of cryptography, key encryption techniques.
CO 5: Develop an understanding of security policies, as well as protocols to implement such policies in the form of message exchanges.
CO 6: Determine appropriate mechanisms for protecting information systems, database management systems and its applications.

UNIT - I	**Introduction to Security**	Lecture Hrs:

Information Security - Confidentiality, Integrity & Availability – Authentication, Authorization & Non-Repudiation – Introduction to Plain Text, Cipher Text, Encryption and Decryption Techniques, Secure Key, Hashing, Digital signature.

UNIT - II	**Symmetric Encryption& Asymmetric Encryption**	Lecture Hrs:

Block cipher, Stream cipher - Data Encryption Standard (DES) - Cipher Block Chaining (CBC) – Multiple Encryption DES - International Data Encryption Algorithm (IDEA) - Advanced Encryption Standard (AES), Asymmetric key generation techniques – Applications of asymmetric encryption methods – RSA Elliptic Curve Cryptography – Homomorphic encryption

UNIT - III		Lecture Hrs:

Digital signature standards - Secure One-time Signatures - Application of Digital Signatures – Diffie Hellman Key Exchange - Elliptic Curve Digital Signature algorithm

UNIT - IV		Lecture Hrs:

Cryptographic Hash Functions- Applications- Simple hash functions and features for ensuring security – Hash functions based on Cipher Block Chaining- Secure Hash Algorithm (SHA) - Message Digest - MD5

UNIT - V		Lecture Hrs:

Authentication Systems – Password and Address – Security Handshake Drawbacks - Authentication Standards – Kerberos- PKI Trust Models -Message Authentication Codes (MAC) – Security features- MAC based on Hash Functions - MAC based on Block Ciphers
Applying cryptography algorithms - Smart cards-Mobile phone security - Electronic passports and ID cards - SDA/DDA/CDA Bank Cards - Financial Cryptography – Secure Payment Systems - Crypto currencies - Bitcoin

Textbooks:
1. D. R. Stinson, Cryptography: Theory and Practice, 3rd Ed. Boca Raton, FL: Chapman & Hall/CRC, 2005. 2. W. Stallings, Cryptography and Network Security: Principles and Practice, 7th Ed. Pearson Publishers, 2017.
Reference Books:
1. J. H. Silverman, A Friendly Introduction to Number Theory, 4th Ed. Boston: Pearson, 2012. 2. C. Kaufman, R. Perlman, and M. Speciner, Network Security: Private Communication in a Public World, 2nd Ed. United States: Prentice Hall PTR, 2002.
Online Learning Resources:

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91106	SIX SIGMA CONCEPTS (21D91106) (PE – II)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

Course Outcomes (CO): Student will be able to

UNIT – I Lecture Hrs:

Introduction to Six-Sigma-Probabilistic models-Six Sigma measures-Yield-DPMO-Quality level-Reliability function using Six-Sigma-MTTF using Six Sigma-Maintenance free operating period- Availability using Six-Sigma-Point availability-Achieved availability-Operational Availability-Examples.

UNIT - II Lecture Hrs:

The Elements of Six Sigma and their Determination-The Quality Measurement Techniques: SQC, Six Sigma, Cp and Cpk- The Statistical quality control (SQC) methods-The relationship of control charts and six sigma-The process capability index (Cp)-Six sigma approach-Six sigma and the 1.5 σ shift-The Cpk Approach Versus Six Sigma-Cpk and process average shift-Negative Cpk-Choosing six sigma or Cpk-Setting the process capability index-Examples.

UNIT - III Lecture Hrs:

Calculating Defects Using Normal Distribution-Relationship between *z* and Cpk-Example defect calculations and Cpk-Attribute processes and reject analysis for six sigma-Quick visual check for normality-Checking for normality using chi-square tests-Example of x^2 goodness of fit to normal distribution test-Transformation data into normal distributions.

UNIT - IV Lecture Hrs:

Basic QC and Six Sigma Tools-The 7 QC Tools-Process Flowchart and Process Mapping-Quality Function Deployment (QFD)- Six Sigma and Design of Experiments (DoE)-DoE Definitions and Expectations-DoE objectives and expectations- DoE Techniques-Steps in conducting a successful DoE-experiment - Types of DoE using orthogonal arrays-Two-level orthogonal arrays-Three-level orthogonal arrays- The Taguchi design.

UNIT - V Lecture Hrs:

Introduction - Product Life Cycle and the Six Sigma Design-Quality Issues-Changes in product design-Changing traditional design communications and supplier involvement-Design process communications needs-Examples.

Textbooks:

1. U Dinesh Kumar, Crocker, Chitra and HaritheSaranga, Reliability and Six Sigma, Springer Publishers.
2. Sung H. Park, Six Sigma for Quality and Productivity Promotion, Asian Productivity Organization.

Reference Books:

1. Sammy G. Shina, Six Sigma for Electronics Design and Manufacturing, McGraw-Hill.

Online Learning Resources:

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91107	RELIABILITY IN ENGINEERING DESIGN (21D91107) (PE – II)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- Understand the concepts of failure mode effects, fault tree analysis, regression setting, liability methods and problem solving process.
- Analyse the concepts of design of FEMA, reliability graph, variance techniques, product laws and project planning.
- Apply the techniques to find the variance, product liability and project planning and costs.
- Design methods to estimate the critical analysis, planning and process of reliable system.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concepts of FEMA methodology, Tree Analysis, strategy of experiment design and problem timing and scheduling.
CO 2: Analyse the examples of FMEA, reliability graph, analysis of variance techniques, product laws and project planning.
CO 3: Apply the methods to evaluate FMEA, failure tree, factorial experiments, product liability and project planning and costs.
CO 4: Design models to evaluate the critical analysis, analysis of variance product planning and development process of the system.

UNIT - I	Failure Mode Effects and Criticality Analysis (FMECA)	Lecture Hrs: 10

Basic Principles and General Fundamentals of FMEA Methodology - FMEA according to VDA 86 - Example of a Design FMEA according to VDA 86 - FMEA according to VDA 4.2 - Example of a System FMEA Product according to VDA 4.2 - Example of a System FMEA Process according to VDA 4.2.

UNIT - II	Fault Tree Analysis (FTA)	Lecture Hrs: 8

General Procedure of the FTA - Qualitative Fault Tree Analysis- Quantitative Fault Tree Analysis - Reliability Graph- Examples.

UNIT - III	Design of Experiments	Lecture Hrs: 12

Analysis of Variance Technique - Strategy of Experimental Design - t test - one and two sample test - F test - one factor at a time - power of analysis of variance tests - Orthogonal design - Completely Randomized design - Randomized Block Design - Latin Square Design-Graeco Latin Squares - Two Factor analysis of variance - Factorial Experiments. Three Factor Experiments - Factorial Experiments in a Regression setting - Incomplete Blocks Design.

UNIT - IV	Product Liability and Planning	Lecture Hrs:12

History - Product Safety Law - Product Liability Law – Defenses - Proof and the Expert Witness Financial Loss - The future of product Liability – Prevention - Degree of Novelty of a Product, Product Life Cycle, Company Goals and Their Effect - Solution Finding Methods - Conventional Methods, Intuitive Methods, Discursive Methods, Methods for Combining Solutions - Examples.

UNIT - V	**Product Development Process**	Lecture Hrs:10
General Problem Solving Process - Flow of Work During the Process of Designing - Activity Planning, Timing and Scheduling, Planning Project and Product Costs, Effective Organization Structures - Interdisciplinary Cooperation, Leadership and Team Behaviour, System Process Administrative Control.		

Textbooks:

1. G. Haribaskaran, “Probability, Queuing Theory & Reliability Engineering”, Laxmi publications, 2nd Edition, 2006.
2. Dale H. Besterfield, Carol Besterfield - Michna and Glen H. Besterfield, “Total Quality Management”, Pearson Publications, Revised Third Edition, 2012.

Reference Books:

1. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, “Probability and Statistics for Engineering and Scientists”, 9th Edition, Pearson Publications, 2010.
2. BrendBertsche, “Reliability in Automotive and Mechanical Engineering”, Springer Publications, 1st Edition, 2011.
3. G. Pahl, W. Beitz, J. Feldhusen and K. H. Grote, “Engineering Design A Systematic Approach”, Springer Publications, 3rd Edition, 2007.

Online Learning Resources:

1. https://www.google.co.in/books/edition/Engineering_Design_Reliability_Handbook/gdHKBQAAQBAJ?hl=en&gbpv=1&dq=RELIABILITY+IN+ENGINEERING+DESIGN&printsec=frontcover

Course Code	21D91108	MONTE CARLO SIMULATION (21D91108) (PE – II)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- Understand the concepts of convergence characteristics, generating random functions, reductions techniques and Monte-Carlo optimization.
- Analyse the concepts of various distribution functions, time dependent process and random search algorithms.
- Apply the techniques to evaluate the efficiency of Monte-Carlo method.
- Develop the algorithms and procedures for discrete event simulation and Monte-Carlo optimization.

Course Outcomes (CO): Student will be able to

CO 1: Understand basic concepts of generating random numbers, reduction techniques and random search algorithms.
CO 2: Analyse about the process of determining random functions, markov chains and regenerative process.
CO 3: Apply the techniques to improve the efficiency of Monte-Carlo method, sampling techniques to reduce the variance.
CO 4: Develop the various methods to generate random functions, for reducing variance and find the optimum Monte-Carlo method.

UNIT – I	Introduction to Monte-Carlo Method	Lecture Hrs: 10

Basic concepts – Features – Efficiency - Convergence Characteristics-Random number generation Linear Congruential generators - Random variate generation - Inverse Transform method-Tabulating technique -Generating random numbers from discrete distributions - Binomial Distribution – Poisson Distribution - Geometric Distribution - Negative Binomial Distribution - Hypergeometric Distribution - Monte Carlo Integration - The Hit or Miss, The Sample - Mean Monte Carlo Methods - Efficiency of Monte Carlo Method - Comparison.

UNIT – II	Generating System Random Functions	Lecture Hrs: 10

Generating random functions from continuous distributions - Exponential Distribution - Gamma Distribution - Beta Distribution - Normal Distribution - Lognormal Distribution - Cauchy Distribution - Weibul Distribution - Chi-Square Distribution - Procedures and Algorithms.

UNIT - III	Reduction Techniques	Lecture Hrs: 10

Variance Reduction Techniques - Importance Sampling - Correlated Sampling - Control Variates Stratified Sampling - Antithetic Variates - Partition of the Region - Reducing the Dimensionality Conditional Monte Carlo - Random Quadrature Method - Biased Estimators - Weighted Monte Carlo Integration.

UNIT – IV	Discrete and Continuous Marko Chains	Lecture Hrs: 12

Discrete event simulation - Poisson process – Time dependent Poisson process - Poisson processes in the plane - Markov chains – Discrete time Markov chains – Continuous time Markov chains Regenerative analysis -Markov chains - Bayesian statistics - The Metropolis Hastings (MH) algorithm -Regenerative Simulation - Point Estimators and Confidence Intervals - Examples of Regenerative Processes - Variance Reduction Techniques - Examples.

UNIT – V	**Monte Carlo Optimization Algorithms**	Lecture Hrs: 10
Monte Carlo Optimization-Random search Algorithms - Efficiency of Random Search Algorithms Local and Integral Properties of Optimum Trial Random searchAlgorithm - Global Optimization - A Closed form Solution – Examples.		
Textbooks:		
1. Roy Billinton and Wenyuan Li, "Reliability Assessment of Electric Power Systems Using Monte Carlo Methods", Plenum Publications (Springer), 1st Edition, 1994.		
Reference Books:		
1. Reuven Y. Rubinstein and Dirk P. Kroese, "Simulation and the Monte Carlo Method, John Wiley & Sons publishers, 3rd Edition, 2016. 2. J. S. Dagpunar, "Simulation and Monte Carlo", Wiley & Sons Publishers, 1st Edition, 2007.		
Online Learning Resources:		
1. https://www.google.co.in/books/edition/Monte_Carlo_Simulation_Based_Statistical/xKMNDgAAQBAJ?hl=en&gbpv=1&dq=MONTE+CARLO+SIMULATION&printsec=frontcover		

Course Code	21D91109	PROBABILISTIC DISTRIBUTIONS SIMULATION LAB (21D91109)	L	T	P	C
Semester	I		0	0	4	2

Course Objectives: To make the student

- Understand the concepts of basic distributions.
- Analyze the procedure for evaluating probability using various distributions.
- Apply the probability distribution concepts in practical problems.
- Develop the program for distributions to find out the optimum probability.

Course Outcomes (CO): Student will be able to

CO 1: Understand the various probability distribution functions.
CO 2: Analyze the steps for evaluating expected value, variance and standard deviations for different distributions.
CO 3: Apply the techniques to improve the probability of the practical system.
CO 4: Develop the programs for probability distribution function for real world problems.

List of Experiments:

Plot the characteristics of pdf and PDF for

1. Binomial Distribution
2. Poission's Distribution
3. Normal Distribution
4. Negative binomial Distribution
5. Log-normal Distribution

Plot the characteristics of pdf, PDF and Reliability for

6. Exponential Distribution
7. Weibull Distribution
8. Raleigh Distribution
9. Uniform Distribution
10. Geometric Distribution
11. Double Exponential Distribution
12. Negative Exponential Distribution

*All the above experiments will be carried out in MATLAB software.

Course Code	21D91110	RELIABILITY LIFE TESTING SIMULATION LAB (21D91110)	L	T	P	C
Semester	I		0	0	4	2

Course Objectives: To make the student

- Understand the basic concepts of regression lines, correlation coefficients and variance.
- Analyze the concepts of advanced distributions for evaluating system probability.
- Apply the techniques to determine the measures of maintenance and Bivariate variables.
- Develop the programs for life testing of Reliability.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concepts of basic distributions, control variables, correlation coefficients.
CO 2: Analyze the techniques to evaluate the probability using advanced distributions.
CO 3: Apply the methods to estimate the maximum likelihood value, analysis of variance and maintenance measures.
CO 4: Develop the programs in MATLAB on distributions, control variables, regression lines for real world problems.

List of Experiments:

1. Chi-Square test for finding the goodness of fit
2. Least Square to fit the regression lines
3. Maximum Likelyhood Estimation (MLE) for normal Distribution
4. X-R chart to obtain control limits and Process control ratio
5. Correlation Coefficient for random variables
6. Determine the variation of data and to test null hypothesis (ANOVA)
7. Evaluating Bivariant variable probability distribution
8. Evaluation of measure of Preventive Maintenance
9. Evaluation of measure of Corrective Maintenance
10. Plot the characteristics of pdf and PDF for Beta Distribution
11. Plot the characteristics of pdf and PDF for Gamma Distribution
12. Plot the characteristics of pdf and PDF for Pareto Distribution
13. Determination of Auto-Correlation Coefficient for random variables
14. Evaluation of Kandall’s Rank Correlation Coefficient Distribution

*All the above experiments will be carried out in MATLAB software.

Course Code	**21D91201**	**R PROGRAMMING (21D91201)**	**L**	**T**	**P**	**C**
Semester	**II**		**3**	**0**	**0**	**3**

Course Objectives:

- To exercise the fundamentals of statistical analysis in R environment.
- Analysis data for the purpose of exploration using Descriptive and Inferential Statistics.
- Understand Probability and Sampling Distributions and learn the creative application of Linear Regression in multivariate context for predictive purpose.

Course Outcomes (CO): Student will be able to

CO 1: Understand the basics in R programming in terms of constructs, control statements, string functions.
CO 2: Understand the use of R for Big Data analytics.
CO 3: Learn to apply R programming for Text processing.
CO 4: Conduct and interpret a variety of Hypothesis Tests to aid Decision Making.
CO 5: Work with Object oriented principles using R Programming.
CO 6: Understand, Analyse, Interpret Correlation and Regression to analyse the underlying relationships between different variables.

UNIT - I	**Introduction**	Lecture Hrs:

Introducing to R – R Data Structures – Help functions in R – Vectors – Scalars – Declarations – recycling – Common Vector operations – Using all and any – Vectorized operations – NA and NULL values – Filtering – Vectorised if-then else – Vector Equality – Vector Element names

UNIT - II	**Matrices, Arrays and Lists**	Lecture Hrs:

Creating matrices – Matrix operations – Applying Functions to Matrix Rows and Columns – Adding and deleting rows and columns – Vector/Matrix Distinction – Avoiding Dimension Reduction – Higher Dimensional arrays – lists – Creating lists – General list operations – Accessing list components and values – applying functions to lists – recursive lists.

UNIT - III	**Data Frames**	Lecture Hrs:

Creating Data Frames – Matrix-like operations in frames – Merging Data Frames – Applying functions to Data frames – Factors and Tables – factors and levels – Common functions used with factors – Working with tables - Other factors and table related functions - Control statements – Arithmetic and Boolean operators and values – Default values for arguments - Returning Boolean values – functions are objects – Environment and Scope issues – Writing Upstairs - Recursion – Replacement functions – Tools for composing function code – Math and Simulations in R.

UNIT - IV	**Object Oriented Programming**	Lecture Hrs:

S3 Classes – S4 Classes – Managing your objects – Input/Output – accessing keyboard and monitor – reading and writing files – accessing the internet – String Manipulation – Graphics – Creating Graphs – Customizing Graphs – Saving graphs to files – Creating three-dimensional plots.

UNIT - V	**Interfacing**	Lecture Hrs:

Interfacing R to other languages – Parallel R – Basic Statistics – Linear Model – Generalized Linear models – Non-linear models – Time Series and Auto-correlation – Clustering

Textbooks:

1. Norman Matloff , "The Art of R Programming: A Tour of Statistical Software Design", No Starch Press, 2011
2. Jared P. Lander, "R for Everyone: Advanced Analytics and Graphics", Addison-Wesley Data & Analytics Series, 2013.

Reference Books:

1. Mark Gardener, "Beginning R – The Statistical Programming Language", Wiley, 2013
2. Robert Knell, "Introductory R: A Beginner's Guide to Data Visualisation, Statistical Analysis and Programming in R", Amazon Digital South Asia Services Inc, 2013.

Online Learning Resources:

Course Code	21D91202	STOCHASTIC PROCESSES (21D91202)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

Course Outcomes (CO): Student will be able to

UNIT – I		Lecture Hrs:

Random Variables, Distribution Functions, Discrete Random Variables-Joint Probability Mass Functions, Continuous Random Variables-Joint Probability Density Functions, Conditional Distributions, Conditional Means and Conditional Variances, N-Variate Random Variables, Special Distributions-Examples, Functions of Random Variables, Expectation and Limit Theorems-Functions of One Random Variables-Functions of Two Random Variables-Functions of n Random Variables-Expectation-Moment Generating Functions-Characteristic Functions-The Laws of Large Number and the Central Limit Theorem-Examples.

UNIT - II		Lecture Hrs:

Stochastic Processes-Definitions-Expectations-Vector process-Gaussian process-Harmonic process-Stationary process-Scalar process, Vector process, Correlation length-Ergodic process-Statistical properties of time averages, Temporal density estimation-Poisson process-Compound Poisson process-Markov process-Examples.

UNIT - III		Lecture Hrs:

Stochastic Calculus-Modes of convergence-Stochastic differentiation-Statistical properties of derivative process, Spectral analysis of derivative processes. Stochastic integration-Statistical properties of stochastic integrals, Integration of weakly stationary processes, Riemann–Stieltjes integrals.

UNIT - IV		Lecture Hrs:

FokkerPlanck–Kolmogorov Equation-Chapman–Kolmogorov equation Derivation of the FPK equation-Derivation using Itô’s lemma-Solutions of FPK equations for linear systems-Short-time solution-Improvement of the short-time solution. Path integral solution-Markov chain representation of path integral. Exact stationary solutions- Examples. Kolmogorov Backward Equation-Derivation of the backward equation-Reliability.

UNIT - V		Lecture Hrs:

Structural Reliability-Modes of failure-Level crossing-Single level crossing, Method of counting process, Higher order statistics of level crossing, Dual level crossing, Local minima and maxima, Envelope processes-Vector process-First-passage reliability based on level crossing-First-passage time probability – general approach-Example of SDOF linear oscillators, Common safe domains, Structural fatigue-S-N model, Rainflow counting, Linear damage model.

Textbooks:

1. Jian-Qiao Sun, Stochastic Dynamics and Control, Elsevies Publishers.
2. Papoulis, Probability, Random Variables, and Stochastic Processes, McGraw-Hill.

Reference Books:

1. Hwei P. Hsu, Probability, Random Variables, and Random Processes, Schaum’s Outline Series, McGraw-Hill.

Online Learning Resources:

Course Code	21D91203	RISK ASSESSMENT AND MANAGEMENT (21D91203) (PE – III)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

- To help students in conduct various risk assessment analysis.
- To study about human reliability techniques, various elements and process of terotechnology, risk management, spare parts management and use of verification and validation in life cycle analysis.

Course Outcomes (CO): Student will be able to

CO 1: Amine features of risk/safety management systems, Conduct various risk assessment analysis and carry out risk assessment.
CO 2: Assess Human reliability and associated elements, Human Reliability Assessment techniques.
CO 3: Recommend and implement Terotechnology concepts.
CO 4: Utilise Risk prioritization techniques and spare parts management philosophies for effective risk management.
CO 5: Examine Verification and validation in life cycle analysis of a product.

UNIT – I Lecture Hrs:9

Basic concepts of Risk-Analysis-Process-planning and Assessment-Risk treatment-Risk analysis methods-Coarse Risk Analysis-Job Safety Analysis-FMEA-Hazard and Operability Studies-SWIFT-Bayesian networks.

UNIT – II Lecture Hrs:9

Human Reliability-Human Errors-Characteristics-Modes of Error detection-Human and Technical reliability-Task Performance-Human Reliability Assessment techniques-Technique for Human error Rate Prediction (THERP)-Human performance data-Human Reliability Enhancement. Human error in maintenance-System Life Cycle-Reasons for maintenance error-Reducing human errors-Prediction techniques-Markov model-Fault Tree Analysis-Examples.

UNIT – III Lecture Hrs:9

Terotechnology-Definitions-System-Process-Programmes-Total Productive maintenance-Strategies-Training Programmes-for project operation managers-maintenance supervisors.

UNIT – IV Lecture Hrs:9

Risk management-Objectives-Definitions-Process-Risk Identification and Approaches-Risk Statement-Risk Prioritization-Borda Algorithm-Value function approach-Ranking-Risk events-Additive value model-Formulations-Incorporating uncertainty-models-Progress monitoring. Spare Parts Management-Inventory Control-Functional Classifications-Advantages-Features-Economic order quantity and its model-Inventory Control approaches-Multi item Inventory control-Classifications-Man power resource and Spares requirement planning-Flow chart-Examples.

UNIT – V Lecture Hrs:9

Verification and Validation-Basic concepts-Management-Planning-Requirements-Systems approaches-Managing Plan-Effectiveness measures-Risk management-Flow Chart-Communication Structures-Internal and Independent information flows. Life Cycle Analysis-Traceability Analysis-Interface Analysis-Phase dependent analysis-Testing-Hierarchy of test documents.

Textbooks:
1. TerjeAven, Risk Analysis Assessing Uncertainties beyond Expected Values and Probabilities, John Wiley and Sons Publication. 2. Sue Cox and Robin Tait, Safety, Reliability and Risk Management: an integrated approach, Second edition, Butterworth-Heinemann Publications. 3. B. S. Dhillon, Engineering Maintenance a Modern Approach, CRC Press.
Reference Books:
1. K. Gupta, Reliability, Maintenance and Safety Engineering, University Science Press. 2. Analytical Methods for Risk Management A Systems Engineering Perspective, Paul R. Garvey, RC Press. 3. Marcus S. Fisher, Software Verification and Validation an Engineering and Scientific Approach, Springer Publishers.
Online Learning Resources:

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91204	MAINTENANCE ENGINEERING AND MANAGEMENT (21D91204) (PE – III)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

This course is designed to introduce basic concepts of maintenance and reliability to the students, to introduce various methods of reliability analysis with real time problems with constraints and to make understanding the applications of Reliability and Maintenance analysis in different types of systems.

Course Outcomes (CO): Student will be able to

CO 1: The students will be able to use statistical tools to characterize the reliability of an item and determine the reliability of a system, and will also understand the application of maintenance strategies in a manufacturing environment;

CO 2: The students will be able to establish maintenance strategies according to system characteristics and design transition programs to implement these strategies.

CO 3: The students will develop ability in formulating suitable maintenance strategies to enhance system reliability of a manufacturing system

CO 4: Student will be able to apply concepts of TPM, RCM, & FMECA in managing the manufacturing organization with highest possible levels of reliability/ availability.

UNIT – I Lecture Hrs:9

Maintenance engineering objectives-Basic principles and approaches-Types of maintenance-Specifications and functions-Systems approach-performance indices-planning and control-Strategy.

UNIT – II Lecture Hrs:9

Maintenance management and control-functions and organization-critical maintenance-effective elements-project control methods-control indices - Maintainability-Concepts-tasks-modeling and allocation-prediction-FMECA-reliability and maintainability trade off-Design for maintainability-design methods.

UNIT – III Lecture Hrs:9

Preventive maintenance-elements and principle-measures-mathematical models-Advantages and disadvantages - Corrective maintenance-types-measures-mathematical models-effective failure rate equations - Reliability Centered Maintenance-goals and principles-components-predictive testing and Inspection techniques-effective measurement indicators-Advantages.

UNIT – IV Lecture Hrs:9

Quality in Maintenance-Processes-Control Charts-Post maintenance testing-Maintenance Safety-maintenance tasks-improving safety-personnel safety.

UNIT – V Lecture Hrs:9

Maintenance costing-factors-budget type and approaches-labor cost estimation-material cost estimation-cost estimation model-cost related indices-economic analysis-Convexand Concave costs-profit and life cycle cost tradeoffs.

Textbooks:

1. A. K. Gupta, Reliability, Maintenance and Safety Engineering,
2. B. S. Dhillon, Engineering Maintenance a Modern Approach, CRC Press.

Reference Books:
1. Charles E. Ebeling, Reliability and Maintainability Engineering, Tata McGraw Hill, 2000.
Online Learning Resources:

Course Code	21D91205	RELIABILITY OPTIMIZATION (21D91205) (PE – III)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

- Understand the concepts of redundant systems, optimization models for reliability optimization.
- Analyse the concepts of heuristic methods, different optimization techniques, reliability for constrained problem.
- Apply the methods to improve the reliability of the complex system.
- Design the new models for redundant systems and estimate the reliability of the system.

Course Outcomes (CO): Student will be able to

CO 1: Understand the redundancy concepts, heuristic approaches for reliability, constrained problem, programming methods.
CO 2: Analyse the concepts of optimization techniques, dynamic programming methods and integer programming methods.
CO 3: Apply the techniques to evaluate the reliability of the redundant systems.
CO 4: Develop the novel methods to optimize the reliability of the dynamic systems.

UNIT - I	Optimization Techniques for System Reliability with Redundancy	Lecture Hrs: 10

Partially redundant systems - Standby redundant systems - Hot, Cold and Warm Standby redundancy concepts - perfect switching imperfect switching - standby redundancy calculations - Component versus unit redundancy - Weakest Link Technique - Mixed Redundancy - Redundancy Optimization - Double Failures and Redundancy - Comparison of various Redundant Systems.

UNIT - II	Optimization of System Reliability	Lecture Hrs: 10

Systems Model - Statement of the various optimization problems - Heuristic Methods applied to optimal systems reliability - A heuristic method: Sharma and Venkateswran's Approach, Aggrawal's Approach, Mishra's Approach, Ushakov's Approach, Nakagawa and Nakashima's Approach.

UNIT - III	Dynamic Programming Applied to Optimal System Reliability	Lecture Hrs: 12

Dynamic programming applied to optimal systems reliability - Basic dynamic programming approach - Dynamic programming approach using Lagrange multipliers - The discrete maximum principle applied to optimal systems reliability - Sequential Unconstrained Minimization Technique (SUMT) applied to optimal systems reliability - Generalized Reduced Gradient method (GRG) applied to optimal Systems reliability.

UNIT - IV	Method of Lagrangian Multipliers and KHUN-TUCKER conditions in Optimal System Reliability	Lecture Hrs: 12

Method of Lagrange multipliers-single constraint problem-single linear constraint problem-two linear constraint problem-Generalized Lagrangian function method applied to optimal systems reliability-Generalized Lagrangian problem-computational procedures- KUHN-TUCKER conditions in optimal systems reliability and for the two linear constraint problem-The geometric programming applied to optimal systems reliability-Examples.

UNIT - V	**Integer Programming and Other methods applied to the System Reliability Optimization Problems**	Lecture Hrs: 10
Integer programming applied to optimal systems reliability – Introduction-The partial Enumeration method-The Gomory Cutting plane method-The branch and bound method-The Geoffrion Implicit Enumeration method-Parametric method-Linear programming-Separable Programming Methods- Examples.		

Textbooks:

1. F.A. Tillman, C. L. Hwang & W. Kuo, "Optimisation of systems Reliability", Marcel Dekker Inc., 1st Edition, 1980.
2. Singiresu S. Rao, "Engineering Optimization Theory and Practice", John Wiley & Sons, 4th Edition, 2009.

Reference Books:

1. E. Balagurusamy, "Reliability Engineering", McGraw Hill Education, 1st Edition, 2017.
2. J. K. Sharma, "Operations Research Theory and Applications", Macmillan Publications, 4th Edition, 2006.

Online Learning Resources:

1. https://www.google.co.in/books/edition/Stochastic_Reliability_Modeling_Optimiza/_9h1UN5R-M0C?hl=en&gbpv=1&dq=RELIABILITY+OPTIMIZATION&printsec=frontcover

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91206	STATISTICAL QUALITY CONTROL (21D91206) (PE – IV)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives:

- To help students understand the concepts underlying statistical quality control and to develop their ability to apply those concepts to the design and management of quality control processes in industries.
- Major topics include history and overview of the state of the art of quality control methodologies, tools for descriptive and predictive statistical analysis, design and use of various control charts for quality control, process characterization and capability analysis, R&R gauge capability studies, design of experiments, acceptance sampling and continuous improvement.
- The emphasis will be on ensuring that the students gain both a broad perspective of quality control as well as the technical skills necessary to implement quality control in any industrial setting.

Course Outcomes (CO): Student will be able to

CO 1: Understand the philosophy and basic concepts of quality improvement.
CO 2: Describe the DMAIC process (define, measure, analyze, improve, and control).
CO 3: Demonstrate the ability to use the methods of statistical process control.
CO 4: Demonstrate the ability to design, use, and interpret control charts for variables.
CO 5: Demonstrate the ability to design, use, and interpret control charts for attributes.
CO 6: Perform analysis of process capability and measurement system capability.
CO 7: Design, use, and interpret exponentially weighted moving average and moving average control charts.

UNIT – I	**Quality Control**	Lecture Hrs:9

Quality, quality control, factors affecting quality, methods of control, chance causes and assignable causes. Quality control and Quality assurance, Quality Costs, Organization for quality, Quality circles, and Statistical process control.

UNIT – II	**Control Charts**	Lecture Hrs:9

Statistical process control –Control charts for variables and attributes. Process and machine capabilities. 6 sigma concept.

UNIT – III	**Acceptance Sampling**	Lecture Hrs:9

Types of sampling, sampling inspection, inspection by Attributes and Variables, Role of acceptance sampling , Procedure for sampling inspection, single, double, multiple sequential sampling plans, O.C. Curves, quality indices for acceptance sampling plans , acceptance sampling by attributes, AQL , LTPD , AOQL – Sampling plans.

UNIT – IV	**Total Quality Management**	Lecture Hrs:9

Quality management system, Definition of TQM, Principles of TQM, Organizational structure of TQM, Total quality control, Total employee involvement, Bench marking – Principles and Procedures, ISO9000 and quality management system. ISO9000 series, quality audits.

UNIT – V	**Tools and Techniques for TQM**	Lecture Hrs:9

Ishikawa diagrams, Pareto diagrams, Histograms, Scatter diagrams, Process Flow Diagram, Check Sheet, Stratification, Quality Function Deployment- House of quality, procedure to carry out QFD, Failure Mode and Effects Analysis, Fault tree analysis, Poka-Yoke, Continuous Process Improvement – Kaizen, PDCA Cycle. House Keeping – 5S principles.

Textbooks:

1. Jain K.C. &Chitale. A.K., Quality Assurance and TQM- Khanna Publisher, 1998.
2. Sharma S.C., Inspection, Quality control and Reliability- Khanna Publishers, 1998.
3. Srinath L.S., Reliability Engineering – Affiliated East West Press, 1975.

Reference Books:

1. Juran.J.M. &Frank.M.Gryna - Quality Planning and Analysis TMH, 1995.
2. Gene L., Grant and Others, Statistical Quality Control – McGraw Hill, 1988.
3. Douglas C Montgomery, Introduction to Statistical Quality Control, John Wiley, Seventh Edition, 2012.

Online Learning Resources:

1. https://onlinecourses.nptel.ac.in/noc20_mg18/preview
2. https://nptel.ac.in/courses/110/105/110105088/
3. https://nptel.ac.in/courses/116/102/116102019/
4. https://nptel.ac.in/courses/116/102/116102019/

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91207	POWER SYSTEM RELIABILITY (21D91207) (PE – IV)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

- Understand the impact of maintaining reliability of the Power System components.
- Analyse the different models of system components in reliability studies.
- Apply the probabilistic and other methods for evaluating the reliability of generation, transmission and distribution system.
- Design the techniques to estimate the reliability of various other components such as sub-station, breakers etc.,

Course Outcomes (CO): Student will be able to

CO 1: Understand the basic probability methods to evaluate the reliability of the power system.
CO 2: Analyze the frequency and duration methods for reliability evaluation.
CO 3: Apply the techniques for reliability evaluation of power system.
CO 4: Develop the mythologies to determine the reliability of the enhanced power system.

UNIT - I	**Generating System Reliability Analysis – I**	Lecture Hrs: 10

Generation system model – Capacity outage probability tables – Recursive relation for capacitive model building – Sequential addition method – Unit removal – Evaluation of loss of load and energy indices – Examples.

UNIT - II	**Generating System Reliability Analysis – II**	Lecture Hrs: 12

Frequency and Duration methods – Evaluation of equivalent transitional rates of identical and non-identical units – Evaluation of cumulative probability and cumulative frequency of non-identical generating units – 2-level daily load representation - Merging generation and load models – Examples.

UNIT - III	**Bulk Power System Reliability Evaluation**	Lecture Hrs: 8

Basic configuration – Conditional probability approach – System and load point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model – Common mode failures.

UNIT - IV	**Distribution System Reliability Analysis – I (Radial Configuration)**	Lecture Hrs: 10

Basic Techniques – Radial networks – Evaluation of Basic reliability indices, performance indices - Load point and system reliability indices – Customer oriented, loss and energy oriented indices – Examples.

UNIT - V	**Distribution System Reliability Analysis - II (Parallel Configuration)**	Lecture Hrs: 10

Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects – Common mode failures – Evaluation of various indices – Examples.

Textbooks:

1. Roy Billinton and Ronald N. Allan, "Reliability Evaluation of Power Systems", Plenum Press (Springer), 2nd Edition, 1992.
2. J. Endrenyi, "Reliability Modeling in Electric Power Systems", John Wiley & Sons, 1st Edition, 1978.

Reference Books:	
1.	Chanan Singh, PanidaJirutijaroen and JoydeepMitra, "Electric Power Grid Reliability Evaluation", IEEE Press Wiley, 1st Edition, 2018.
2.	Ali A. Chowdhury and Don O. Koval, "Power Distribution System Reliability Practical Methods and Applications", A John Wiley & Son, Inc. Publications, 1st Edition, 2008.
Online Learning Resources:	
1.	https://www.google.co.in/books/edition/Advances_in_System_Reliability_Engineeri/pKh7DwAAQBAJ?hl=en&gbpv=1&dq=POWER+SYSTEM+RELIABILITY&printsec=frontcover

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91208	INTELLIGENT ALGORITHMS (21D91208) (PE – IV)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

- Understand and use the concepts of Artificial Intelligence i.e Fuzzy Logic, Neural Network and Genetic Algorithms to the system.
- Analyze the Fuzzy Logic Controller, Neural Network based Controller.
- Apply the Optimization techniques using Genetic Algorithm for real time usage.
- Develop the simulation for all the techniques using MATLAB.

Course Outcomes (CO): Student will be able to

CO 1: Understand the control system is the decision making system (brain) of any physical systems.
CO 2: Analyze the computational intelligence to the controllers so that the controllers becomes optimal, robust and self-learning.
CO 3: Apply the artificial intelligence which includes the Neural networks, Fuzzy Logic and Genetic Algorithms and having vide applications in the field of control system.
CO 4: Develop MATLAB programs and simulation models for all the techniques.

UNIT - I	**Basics of Intelligent control and Data Pre-processing**	Lecture Hrs: 8

Elementary concepts and motivation, Approaches to intelligent control. Architecture for intelligent control, Symbolic reasoning system, rule-based systems, the AI approach, Knowledge representation, Expert systems, Data Pre-Processing: Scaling, Fourier transformation, principal - component analysis and wavelet transformations.

UNIT - II	**Artificial Neural Networks**	Lecture Hrs: 12

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch - Pitts neuron model, simple perceptron, Adaline and Madaline, Feed - forward Multilayer Perceptron, Learning and Training the neural network, Networks: Hopfield network, Self - organizing network and Recurrent network, Neural Network based controller, Case studies: Identification and control of linear and nonlinear dynamic systems using MATLAB / Neural Network toolbox.

UNIT - III	**Genetic Algorithm**	Lecture Hrs: 10

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters, Solution of typical control problems using genetic algorithm, Concept on some other than GA search techniques like tabu search and ant-colony search techniques for solving optimization problems.

UNIT - IV	**Fuzzy Logic System**	Lecture Hrs: 10

Crisp sets and Fuzzy sets, basic fuzzy set operation and approximate reasoning, Introduction to Fuzzy logic modeling and control of a system, Fuzzification, inference and de-fuzzification, Fuzzy knowledge and rule bases.

UNIT - V	**Applications to nonlinear systems**	Lecture Hrs: 12

Fuzzy modelling and control schemes for nonlinear systems, Self-organizing fuzzy logic control, Implementation of fuzzy logic controller using MATLAB fuzzy - logic toolbox. Stability analysis of fuzzy control systems. Intelligent Control for SISO/MIMO Nonlinear Systems. Model Based Multivariable Fuzzy Controller.

Textbooks:

1. Simon Haykin, "Neural Networks: A Comprehensive Foundation", Pearson Education, 2nd Edition, 2003.
2. TimothyJ.Ross, "Fuzzy logic with Engineering Applications", Wiley Publications, 2nd Edition, 2004.
3. David E Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, 1st Edition, 2007.

Reference Books:

1. M.T.Hagan, H. B. Demuth, M. Beale and De Jesus"Neural Network Design", Indian reprint, 2nd Edition, 2014.
2. Fredric M.Ham and IvicaKostanic, "Principles of Neurocomputing for Science and Engineering", McGraw Hill, 1st Edition, 2001.
3. N.K. Bose and P.Liang, "Neural Network Fundamentals with Graphs, Algorithms and Applications", Mc - Graw Hill, 1st Edition, 1996.

Online Learning Resources:

1. https://nptel.ac.in/courses/106/106/106106126/

Course Code	21D91209	NETWROK RELIABILITY SIMULATION LAB (21D91209)	L	T	P	C
Semester	II		0	0	4	2

Course Objectives: To make the student

- Understand the basic concepts of series and parallel systems.
- Analyze the procedure to find MTTR, MTTF for the system.
- Apply the methods to determine limiting state probabilities, basic probability indices and component repairable models.
- Develop the programs to enhance the network reliability using different techniques.

Course Outcomes (CO): Student will be able to

CO 1: Understand about series, parallel, series-parallel system and parallel system.
CO 2: Analyze how to determine the MTTF, MTTR and component and unit redundancy for different networks.
CO 3: Apply the methods to evaluate limiting state probability, basic probability indices for different configuration of the network.
CO 4: Develop the programs in MATLAB to enhance the network reliability for practical system.

List of Experiments:

1. Determination of MTTR Series System
2. Determination of MTTF Parallel System
3. Evaluation of Limiting State Probability
4. Evaluation of Basic Probability Indices for Series System
5. Evaluation of Basic Probability Indices for Parallel System
6. Component and Unit Redundancy using Deterministic method
7. Component and Unit Redundancy using Exponential Distribution
8. Calculate Basic Probability Indices using Cutset approach
9. Basic Probability indices using Series - Parallel System
10. Basic Probability indices using Parallel - Series System
11. Evaluation of individual probabilities and frequencies of Multi Component repairable model

*All the above experiments will be carried out in MATLAB software.

Course Code	21D91210	R PROGRAMMING LAB (21D91210)	L	T	P	C
Semester	II		0	0	4	2

Course Objectives:

- To provide a practical introduction to the R programming language.
- To work with the R environment, including importing external data, manipulating data for specific needs, and running summary statistics and visualisations.

Course Outcomes (CO):

CO 1: Install and use R for simple programming tasks.
CO 2: Extend the functionality of R by using add-on packages
CO 3: Extract data from files and other sources and perform various data manipulation tasks on them.
CO 4: Code statistical functions in R.
CO 5: Use R Graphics and Tables to visualize results of various statistical operations on data.
CO 6: Apply the knowledge of R gained to data Analytics for real life applications.

List of Experiments:

1. Download and install R-Programming environment and install basic packages using install packages() command in R.
2. Learn all the basics of R-Programming (Data types, Variables, Operators etc,.)
3. Write a program to find list of even numbers from 1 to n using R-Loops.
4. Create a function to print squares of numbers in sequence.
5. Write a program to join columns and rows in a data frame using cbind() and rbind() in R.
6. Implement different String Manipulation functions in R.
7. Implement different data structures in R (Vectors, Lists, Data Frames).
8. Write a program to read a csv file and analyze the data in the file in R.
9. Create pie chart and bar chart using R.
10. Create a data set and do statistical analysis on the data using R.
11. Write programs for simple regression and correlation, multiple regression.

References:

1. R Programming For Dummies by JorisMeysAndrie de Vries, Wiley Publications
2. Hands-On Programming with R by Grolemund, O Reilly Publications

Online learning resources/Virtual labs:

1. https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf (Online Resources)

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code	21D91301	PYTHON PROGRAMMING (PE – V)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives:

1. To understand the basics of Scripting Language.
2. To get exposure on problems solving approaches of computer science.
3. To use various packages in solving problems.
4. To develop the skill of designing Graphical user Interfaces in Python.
5. To develop the ability to write database applications in Python.

Course Outcomes (CO): Student will be able to

CO 1: Describe fundamentals of Python programming and its applications.
CO 2: Implement Python programs using data types, Operators and Control statements.
CO 3: Determine Python data structures and its operations for accessing data.
CO 4: Carry out modular programming using functions and packages.
CO 5: Implement the OOPs concepts in Python Programming.
CO 6: Represent the Standard Libraries for Interfaces, graphics and fundamentals of testing.

UNIT - I	Basics of Python	Lecture Hrs:

History of Python, Need of Python Programming, Applications Basics of Python Programming Using the REPL(Shell), Running Python Scripts, Variables, Assignment, Keywords, Input-Output, Indentation.

Types, Operators and Expressions: Types - Integers, Strings, Booleans; Operators-Arithmetic Operators, Comparison (Relational) Operators, Assignment Operators, Logical Operators, Bitwise Operators, Membership Operators, Identity Operators, Expressions and order of evaluations Control Flow- if, if-elif-else, for, while, break, continue, pass.

UNIT - II	Data Structures & Functions	Lecture Hrs:

Data Structures - Lists - Operations, Slicing, Methods; Tuples, Sets, Dictionaries, Sequences. Comprehensions.

Functions - Defining Functions, Calling Functions, Passing Arguments, Keyword Arguments, Default Arguments, Variable-length arguments, Anonymous Functions, Fruitful Functions(Function Returning Values), Scope of the Variables in a Function - Global and Local Variables.

UNIT - III	Modules, Python Packages & Brief Tour of the Standard Library	Lecture Hrs:

Modules: Creating modules, import statement, from import statement, name spacing.

Python packages: Introduction to PIP, Installing Packages via PIP, Using Python Packages Error and Exceptions: Difference between an error and Exception, Handling Exception, try except block, Raising Exceptions, User Defined Exceptions

Brief Tour of the Standard Library - Operating System Interface - String Pattern Matching, Mathematics, Internet Access, Dates and Times, Data Compression, Multithreading.

UNIT - IV	Objects and their Use, Object Oriented Programming	Lecture Hrs:

Objects and Their Use: Software objects, Turtle graphics - Creating a turtle graphics window, The default turtle, Fundamental turtle attributes and behavior, Additional turtle attributes, Creating multiple turtles.

Object Oriented Programming: Encapsulation, Inheritance, and Polymorphism.

UNIT - V	**GUI Programming, Testing**	Lecture Hrs:

GUI Programming - Tkinter Overview - tkinter pragmatics, Documentation, Extensions, structure; tkinter coding alternatives, adding buttons and callbacks-lambda, bound method, callable class object, Binding events; adding multiple widgets, Reusable GUI Components with classes, Dialogs, Entry, check buttons and Radio buttons, Scales, Menus.
Testing: Why testing is required? Basic concepts of testing, Unit testing in Python, Writing Test cases, Running Tests.

Textbooks:

1. Mark Lutz, Learning Python, Orielly Publications, 5th edition, 2013.
2. Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem-Solving Focus,Wiley India Edition, 2016.

Reference Books:

1. VamsiKurama, Python Programming: A Modern Approach, Pearson, 2017.
2. Allen Downey, Think Python, Green Tea Press, 2012.
3. Kenneth Lambert and Juneja B.L., Fundamentals of Python Cengage Learning, 3rd Edition, 2012.

Online Learning Resources:

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code		STATISTICAL TECHNIQUES IN BIG DATA ANALYTICS (PEC – V)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives:

- Learn the different ways of data analysis.
- Be familiar with data streams.
- Learn the mining and clustering.
- Be familiar with the visualization.

Course Outcomes (CO): Student will be able to

CO 1: Demonstrate Sampling techniques using Data Analytic tools.
CO 2: Make use of supervised learning models for data analysis.
CO 3: Demonstrate Real-time Analytics platform applications on streams.
CO 4: Implement clustering algorithms on high dimensional data.
CO 5: Demonstrate the functionality of various frameworks.
CO 6: Illustrate visualization techniques.

UNIT - I	**Basic Statistics**	Lecture Hrs:

Frequency table, histogram, measures of location, measures of spread, skewness, Kurtosis, percentiles, box plot, correlation and simple linear regression, partial correlation, probability distribution as a statistics model, fitting probability distributions, empirical distributions, checking goodness of fit through plots and tests.

UNIT - II	**Introduction to Big Data**	Lecture Hrs:

Introduction to Big Data Platform: Challenges of conventional systems, Web data, Evolution of Analytic scalability, analytic processes and tools, Modern data analytic tools, Statistical concepts.

UNIT - III	**Data Analysis**	Lecture Hrs:

Regression modeling, Multivariate analysis, Bayesian modeling, Inference and Bayesian networks, Support vector and kernel methods, Analysis of time series, Neural networks: learning and generalization, competitive learning, principal component analysis, Fuzzy logic: extracting fuzzy models from data, fuzzy decision trees, and Stochastic search methods.

UNIT - IV	**Mining Data Streams**	Lecture Hrs:

Introduction to Streams Concepts, Stream data model and architecture, Stream Computing, Sampling data in a stream, filtering streams, counting distinct elements in a stream, estimating moments, counting oneness in a window, Decaying window, Real-time Analytics Platform (RTAP) applications: sentiment analysis, stock market predictions.

UNIT - V	**Clustering, Frameworks and Visualization**	Lecture Hrs:

Clustering Techniques: Hierarchical, K- Means, Clustering high dimensional data, Clustering for streams and Parallelism. MapReduce, Hadoop, Hive, MapR, Sharding, NoSQL Databases, S3, Hadoop Distributed file systems, Visualizations, Visual data analysis techniques.

Textbooks:

1. Statistics: David Freedman, PobertPisani& Roger Purves, WW.Norten& Co. 4th Edition 2007.
2. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
3. AnandRajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2012.

Reference Books:

1. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with advanced analystics, John Wiley & sons, 2012.
2. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007 Pete Warden, Big Data Glossary, O‟‟ Reilly, 2011.
3. Jiawei Han, MichelineKamber "Data Mining Concepts and Techniques", Second Edition, Elsevier, Reprinted 2008.

Online Learning Resources:

Course Code		STATISTICAL TECHNIQUES IN MACHINE LEARNING (PEC – V)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives:

- Know descriptive statistics and data visualizations to quickly and more deeply understand the shape and relationships in data.
- Use inferential statistical tests to quickly and effectively quantify the relationships between samples, such as the results of experiments with different predictive algorithms or differing configurations.
- Use estimation statistics to quickly and effectively quantify the confidence in estimated model skill and model predictions.

Course Outcomes (CO): Student will be able to

CO 1: Use statistical methods in machine learning.
CO 2: Calculate and interpret common summary statistics and how to present data using standard data visualization techniques.
CO 3: Evaluate and interpret the relationship between variables and the independence of variables.
CO 4: Calculate and interpret parametric statistical hypothesis tests for comparing two or more data samples.
CO 5: Use statistical resampling to make good economic use of available data in order to evaluate predictive models.
CO 6: Calculate and interpret nonparametric statistical hypothesis tests for comparing two or more data samples that do not conform to the expectations of parametric tests.

UNIT - I	**Introduction**	Lecture Hrs:
Introduction to Statistics, Statistics vs Machine Learning, Examples of Statistics in Machine Learning, Foundation: Gaussian and Summary Stats, Simple Data Visualization, Random Numbers, Law of Large Numbers, Central Limit Theorem		
UNIT - II	**Hypothesis Testing**	Lecture Hrs:
Statistical Hypothesis Testing, Statistical Distributions, Critical Values, Covariance and Correlation, Significance Tests, Effect Size, Statistical Power		
UNIT - III	**Resampling Methods**	Lecture Hrs:
Introduction to Resampling, Estimation with Bootstrap, Estimation with Cross-Validation,		
UNIT - IV	**Estimation Statistics**	Lecture Hrs:
Introduction to Estimation Statistics, Tolerance Intervals Confidence Intervals, Prediction Intervals		
UNIT - V	**Nonparametric Methods**	Lecture Hrs:
Rank Data, Normality Tests, Make Data Normal, 5-Number Summary, Rank Correlation, Rank Significance Tests, Independence Test		
Textbooks:		
1. Jason Brownlee, “Statistical Methods for Machine Learning”, 2019. 2. GianlucaBontempi, “Handbook Statistical foundations of machine learning”, 2nd Edition, 2020.		
Reference Books:		
1. PratapDangeti , “Statistical for Machine Learning”, 2017.		
Online Learning Resources:		

R21 COURSE STRUCTURE &SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(RELIABILITY ENGINEERING)

Course Code		WASTE TO ENERGY (OE)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives: To make the student

- To understand the concept of waste to energy.
- To analyze technical and management principles for production of energy from waste.
- To apply the best available technologies for waste to energy.
- To develop the process for thermal conversion, bio-chemical and waste to energy conversion.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concept of waste to energy.
CO 2: Analyze technical and management principles for production of energy from waste.
CO 3: Apply the best available technologies for waste to energy.
CO 4: Develop the process for thermal conversion, bio-chemical and waste to energy conversion.

UNIT – I	**Introduction to Energy from Waste**	Lecture Hrs: 9

Classification of waste as fuel – Agro based – Forest residue – Industrialwaste– MSW– Conversiondevices–Incinerators – Gasifiers – Digestors.

UNIT - II	**Biomass Pyrolysis**	Lecture Hrs: 9

Pyrolysis – Types – Slow fast – Manufacture of charcoal – Methods – Yields andapplication–Manufacture ofpyrolyticoilsand gases – Yieldsand applications.

UNIT - III	**Biomass Gasification**	Lecture Hrs: 10

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bedgasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifieroperation.

UNIT - IV	**Biomass Combustion**	Lecture Hrs: 10

Biomass stoves – Improved challahs – Types, Some exotic designs – Fixed bedcombustors– Types – Inclined grate combustors – Fluidized bed combustors – Design – Construction andoperation– Operation ofallthe abovebiomasscombustors.

UNIT - V	**Introduction to Biogas**	Lecture Hrs: 10

Properties of biogas (Calorific value and composition) – Biogas plant technology and status – Bio energy system – Design and constructional features – Biomass resources and their classification – Biomassconversionprocesses– Thermochemicalconversion– Directcombustion– Biomassgasification– Pyrolysisandliquefaction– Biochemicalconversion– anaerobicdigestionTypesofbiogasPlants–Applications– Alcoholproductionfrombiomass– Biodieselproduction– Urbanwastetoenergyconversion – BiomassenergyprogrammeinIndia.

Textbooks:

1. Non-ConventionalEnergy,Desai,Ashok V.,WileyEasternLtd., 1st Edition,1990.
2. BiogasTechnology-APracticalHandBook-Khandelwal,K.C.andMahdi,S.S.,Vol.I&II,TataMcGrawHillPublishing Co.Ltd.,1st Edition, 1983.

Reference Books:

1. Food,FeedandFuelfromBiomass,Challal,D.S.,IBHPublishingCo.Pvt.Ltd.,1st Edition, 1991. 2. BiomassConversionandTechnology,C.Y.WereKo-BrobbyandE.B.Hagan,JohnWiley&Sons,1st Edition ,1996.
Online Learning Resources:
1. https://www.digimat.in/nptel/courses/video/103107125/L01.html 2. https://nptel.ac.in/courses/103/107/103107125/